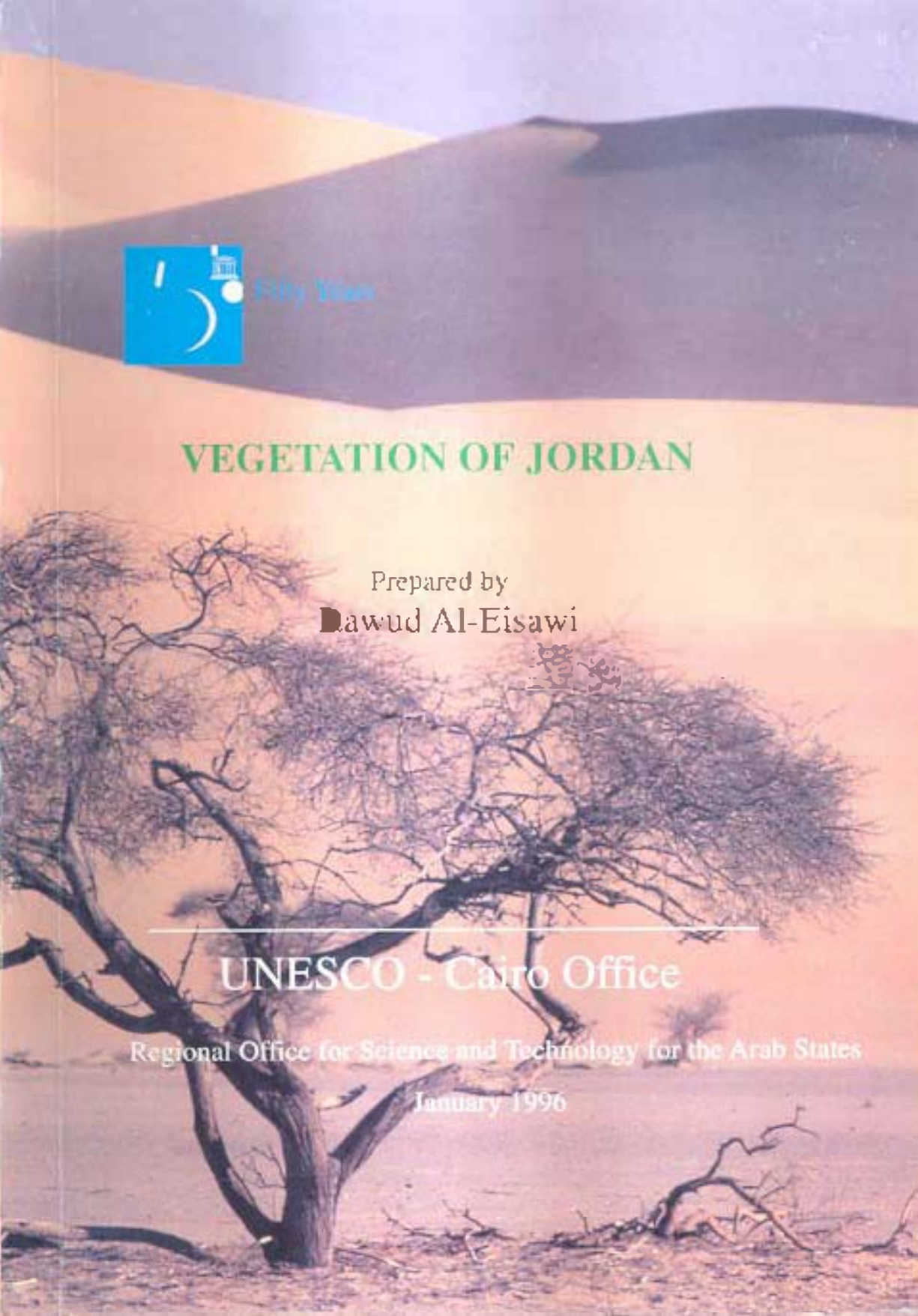

VEGETATION OF JORDAN

Prepared by
Dawud Al-Eisawi

UNESCO - Cairo Office

Regional Office for Science and Technology for the Arab States

January 1996

Fifty Years

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UNESCO wishes to gratefully acknowledge the contribution of Prof. Dawud Al-Eisawi for providing the camera-ready copy of this document.

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PREFACE

Jordan is part of the Middle East where the earliest civilization and activity of mankind originated. Accordingly, land use for agriculture as well as selection of wild plants for domestic use was initiated in this part of the world. In ancient time human activities were not so prominent as to have such damaging effect on the ecosystem that we observe nowadays.

The huge increase of human population in recent times, which has doubled within the past 50 years, associated with similar magnitude of increase of human demand on food have severely affected the general ecosystem of the world. The destruction of land and aquatic ecosystem have led, in some cases, to human disasters and irreversible sequence of changes due to the destruction of the green cover of the earth. The destruction of the tropical forests, spread of polluting industries, expansion of road networks and over-exploitation of natural resources are some of the major causes of human impact on the ecosystem. Unfortunately, man himself is most affected by these human activities.

In view of the above UNESCO Cairo Office has supported and encouraged research and education activities related to the protection of the biosphere in relation to human activities. This book is one outcome of such an approach. It is prepared in the framework of the MAB programme of UNESCO. The book encompasses various subjects related to vegetation, biodiversity, influence of man on environment and conservation. It is hoped that it will represent a useful contribution towards the sustainable use of natural resources in the region and maintaining the delicate balance of its ecosystem and the environment.

UNESCO Cairo Office has provided modest financial contribution to help Prof. Dawud Al-Eisawi to complete this work. He accomplished that with great patience and dedication of a true scientist. The draft copy of the book was reviewed by Prof. Mohammed Abdelfattah El-Kassas and Prof. Irina Springuel. UNESCO Cairo Office is pleased to acknowledge with thanks and appreciation the scientific work of the author and the reviewers and is grateful to all of them. The office would like also to acknowledge the close cooperation and support provided by the Jordan National Commission of UNESCO and the Jordanian MAB Committee in completing this work.

Adnan Shihab-Eldin
UNESCO Cairo Office

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INTRODUCTION

It is the first attempt to a write special book about the vegetation of Jordan. Before this book there was no specific reference related to the vegetation of Jordan. There are few recent publications by the author related to studies concerned with specific locations in Jordan as well as a general paper about the vegetation of Jordan. Previous studies by other workers were made 30-40 years ago which can never reflect the present status. It is well known that the destruction to the ecosystem has reached its maximum during the past 40 years during which major alternations have taken place.

This book covers the following subjects: chapter one which is an introduction to the geology of Jordan as kindly provided by prof. A. Abed (Geology Department, University of Jordan), while chapter two presents the physical characteristics of Jordan encompassing its topography, altitude, rainfall, temperature and soil types.

Chapter three deals with the biogeographical regions of Jordan based on the analysis of climatic conditions in relation to their distribution as given by the meteorological stations. Jordan is classified into four biogeographical regions based on overall physical conditions, climatic regions and biological characteristics.

Chapter four presents the vegetation types in Jordan based on field investigations. The recognized vegetation types are described by including their location and associations or leading species of each type. Mixed forest vegetation type which was recognized by some investigators has been discussed to verify its status.

Vegetation of specific places in Jordan, that are often needed by researchers in other fields of specialization, is covered in chapter five. Selected areas such as Wadi Shuaib, Karak area, Dana Reserve, Dead Sea, Wadi Araba, Azraq basin, Shaumari Reserve, Marginal land and Eastern Desert (Badia) are also discussed.

Chapter six deals with biodiversity as an important current topic globally as well as in Jordan. Definitions for biodiversity, causes of international biodiversity loss, causes of local biodiversity loss and importance of biodiversity as genetical resources are presented.

Chapter seven focuses on the analysis of the flora of Jordan in terms of richness, number of families, genera and species.

Man influence on the ecosystem and natural cover is most harmful to the existing ecological balance, especially with the recent advancement in science and technology. Therefore, chapter eight is provided to present certain human impacts on various parts of Jordan, such as mountains, Jordan Valley, Dead Sea, Wadi Araba, Marginal lands and the Eastern Desert.

Chapter nine is designated to present the importance of conservation, methods of conservation and reserves in Jordan. One hopes to minimize the loss of biodiversity, to conserve what is left and reintroduce what was lost from Jordan due to irrational use of natural resources. Methods of conservation are discussed and a brief summary is given on natural reserves in Jordan.

Vegetation types, and human impact activities have been photographed through time and are included in this text to give a closer idea about the subject under consideration. These photographs were taken as slides by the author. The quality of the prints is at most 50-70% of the original corresponding slides.

A bibliography list, compressing relevant references, and a general index for various subjects are provided at the end of the text.

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1. GEOLOGICAL BACK GROUND

1.1. The Geology of Jordan

Geological works on Jordan started as early as 1868, when **LARTET** (1869) discussed the origin of the depression along Western Jordan. By the turn of the 19th. century the German geologist **BLANKENHORN** (1896) wrote several papers on the geology of Jordan Levant. **BLAKE** and **IONIDES** (1939) wrote a lengthy report on the geology of Jordan and its water resources. **QUANELL** (in **BURDON**, 1959) mapped the country between 1948-1951 and produced the first detailed geological map 1-250.000 (3 sheets). The German Geological Mission to Jordan 1961-1968 remapped Jordan and a five sheet 1-250.000 was produced (**BURDON**, 1974). More recently, the Natural Resources Authority of Jordan has been mapping the country since 1984 on a scale 1-50.000 and more than 15 bulletins are now published.

Although, small in area, Jordan has a rock record representing all the geological eras and lithologies. Strata are getting younger from South to North due to the presence of the Precambrian basement in the South. They also get younger Eastwards due to the presence of the Dead Sea Transform and the associated uplift in the West.

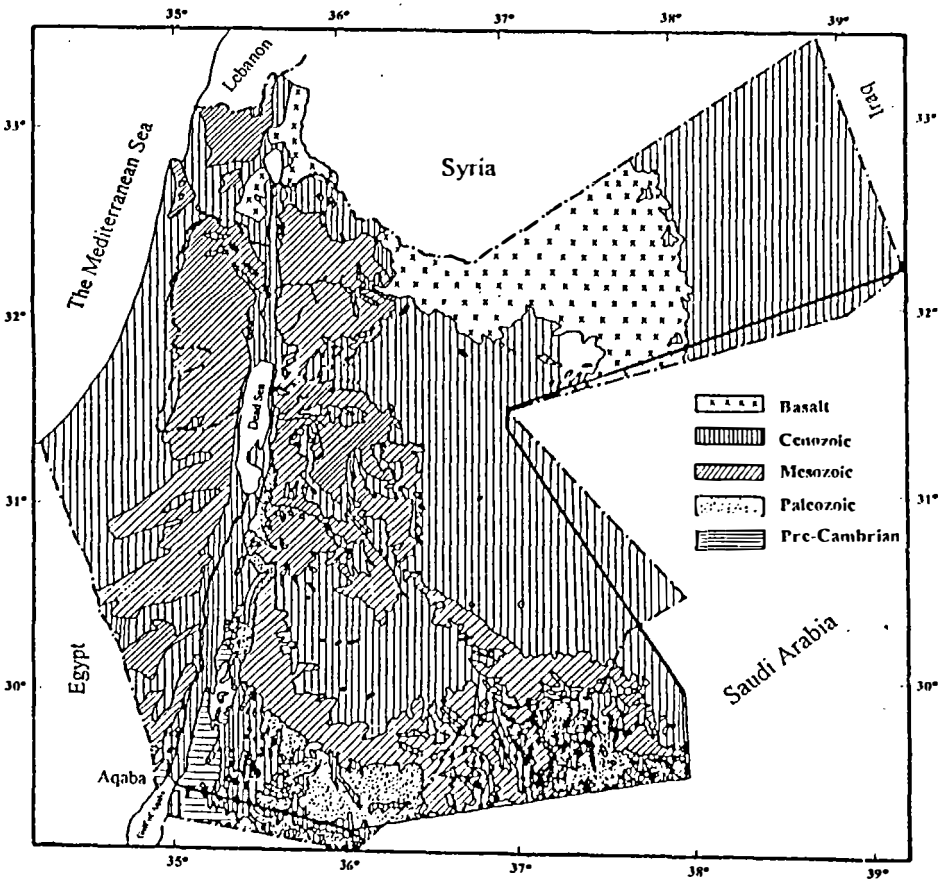
Precambrian basement (800-550 Ma), crops out around Aqaba in the South and along the Eastern shoulder of Wadi Araba till the South-Eastern tip of the Dead Sea (**Map 1.1**). The recognized rocks are:

1. Metamorphic, which are the oldest. They range up to high grade schists and pass even to migmatites. Most of them are present as isolated pendants on later granitic intrusions. Examples are those of Wadi Araba and SE Aqaba.

2. Igneous rocks which are dominantly granitic of various type (690-550 Ma), but other varieties like quartz porphyry, pegmatites, diorites and granodiorites are present. Several dike phases intruded the whole basement complex. Granite makes up more than 90% of the basement.

3. Metasediments (≅600 Ma) are made of conglomerates (e.g. Sarmuj) filling depression within the Precambrian basement.

Map 1.1. Showing general geology of Jordan.



Paleozoic sandstones are outcropping in the extreme, South passing into Saudi Arabia. They overly the basement, also along the Eastern shoulder of Wadi Araba and continue up to the North-Eastern tip of the Dead Sea. Lower Paleozoic is only present in the outcrop (Cambrian-Silurian). Younger systems are found in the subsurface in the North. Rocks are dominantly sandstones with minor shales and mud rocks.

Mesozoic rocks are widespread in Jordan. The Cretaceous is by far the most important. It extends from Ras An-Naqab in the South to the extreme North of Jordan. The upper Cretaceous is made of a carbonate regime in its lower part and mixed mineralogy (carbonate, chert, phosphorite and oil shale) in its upper part. Thus, the Western high lands in central and Northern Jordan are made of carbonates, while somewhere to the East (still in central and North) chert, phosphorites are present.

Bellow this transgressive regime of the Upper Cretaceous, the Kurnub sandstone, dominantly fluvial, is present and crops out in deeper wadies all over Jordan except for the Paleozoic sandstones in the extreme South.

More over, Triassic and Jurassic sediments can be found as isolated outcrops in deeper wadies. They are made of sandstones, dolomite, gypsum and the like.

During the Cenozoic, the Paleogene deposits are only present as marine carbonates (marl, chalk) phosphorite and chert. They are well present in the Eastern and Northern parts of the country.

The Sea had left Jordan since the upper Eocene and no marine strata is present after that. Sediments younger than the Eocene are to be found in the newly formed Dead Sea Transform (Miocene) as lake sediments, either saline or fresh water, carbonate and evaporites conglomerates and gravels as alluvial fans, calcrete on the high lands. Also, Quaternary deposits are found in the Azraq depression, an ancient playa, where various type of evaporites, carbonate, diatomites and clays were deposited.

Neogene basalts are wide spread in Jordan as isolated volcanos (central Jordan) or as a huge plateau basalt field in NE Jordan (11.000 Sq. km).

Structurally, the most important feature is the Dead Sea Transform which started sometimes in the Middle Miocene. Since then, but continuously, Jordan block, as part of the Arabian Plate, has been moving (≅ 0.7 cm/year) to the NE relative to Palestine-Sinai block. The total strike-slip movement is measured as 107 km.

2. PHYSICAL CHARACTERISTICS OF JORDAN

2.1. Topography

2.2. Altitude

2.3. Rainfall

2.4. Temperature

2.5. Soil

2.1. Topography

Jordan is a small country (90,000 Km^2) and as a result of its special topography, considerable climatic variations are very well marked within this limited area.

Jordan can be subdivided longitudinally from North to South into three major topographical regions: **(Map 2.1)** .

1. The Rift Valley: which extends from lake Tiberias in the North down to the Gulf of Aqaba in the South. This region is the lowest part on earth which reaches the maximum (about 400 m.) below sea level in the Dead Sea area.

2. The Mountain Ranges: extends from the North in Irbid down to the South in Ras An-Naqab. This region is interrupted several times by some depressions in the wadi areas like that of Wadi Mujeb. Some of these mountains reach about 1500 m. above sea level.

3. The Eastern Desert: comprising the majority of the country and links with Arabian Desert at the borders of three Arab Countries, Syria, Iraq and Saudi Arabia from the North, East and South respectively.

These regions have been the main critical factors of extreme climatic variations within the restricted area of Jordan.

2.2. Altitude

The altitude in Jordan varies from 400 m below sea level to about 1854 m above sea level. The altitude in the Jordan valley (part of the Rift Valley) area ranges from 200m above sea level descending down to the Dead Sea at -400 m. The same thing applies to Wadi Araba (part of The Rift Valley) where it starts at the Southern end of the Dead Sea with an altitude of -400 m. and extends South to the Gulf of Aqaba at the Red Sea. The altitude fluctuates from -400 m at the Dead Sea to 100-200 m above sea level in some parts of Wadi Araba.

The altitude of the mountain ranges varies from about 600-1754 m. The highest mountain was recorded in Jabal Rum in Wadi Rum area.

Recently, a new mountain called Um Ad-Damy has been recorded to be the highest, with an altitude of 1854. This mountain was part of Saudi Arabia before the alteration of the borders with Jordan.

Generally speaking the Mountains of Ash-Sharah in Southern Jordan extends between the area from Tafila to Ras An-Naqab, where the highest ranging from 1200-1650 m.

The mountain ranges as extending from North in Irbid to South near Aqaba are interrupted by series of Wadi depressions such as Wadi Zarka (Zarka river), Wadi Shuaib, Wadi Walah, Wadi AL-Mujeb (**Fig. 2.1**), Wadi AL-Ḥasa and Wadi Rum.

The Eastern desert of Jordan is almost a flattened area with occasional raised places forming hump like hilly areas. The altitude in general ranges from 600 - 700 m. In the Northern part of the Eastern desert the height might reach 1000-1200 m. at the Northern borders with Syria, especially at Ath-Thallaj mountain. Ath-Thallaj in Arabic means very cold or freezing conditions. In fact this area is classified as very cold desert with occasional snow fall during cold seasons.

2.3. Rainfall

Data of 31 stations for the period of 1966-80 have shown variations of precipitation with a range of 50-500 mm. annually. The lowest amount of rain was recorded in Wadi Araba 50 mm. while the highest was in Ras Muneef in Ajloun area 500 mm. (**Map 2.2**).

The rain usually falls during Winter and Spring starting as early as October and may extend as late as May. Usually the maximum amount will be during January. The amount and the period of rainfall are very variable and fluctuate from year to year, often there is barely any rain until December or even January and at some other times there will be no rain after the middle or even early March. Generally speaking the amount of rainfall decreases from North to South and from West to East.

Map 2.1. Map of Jordan Showing border and the three topographical regions.

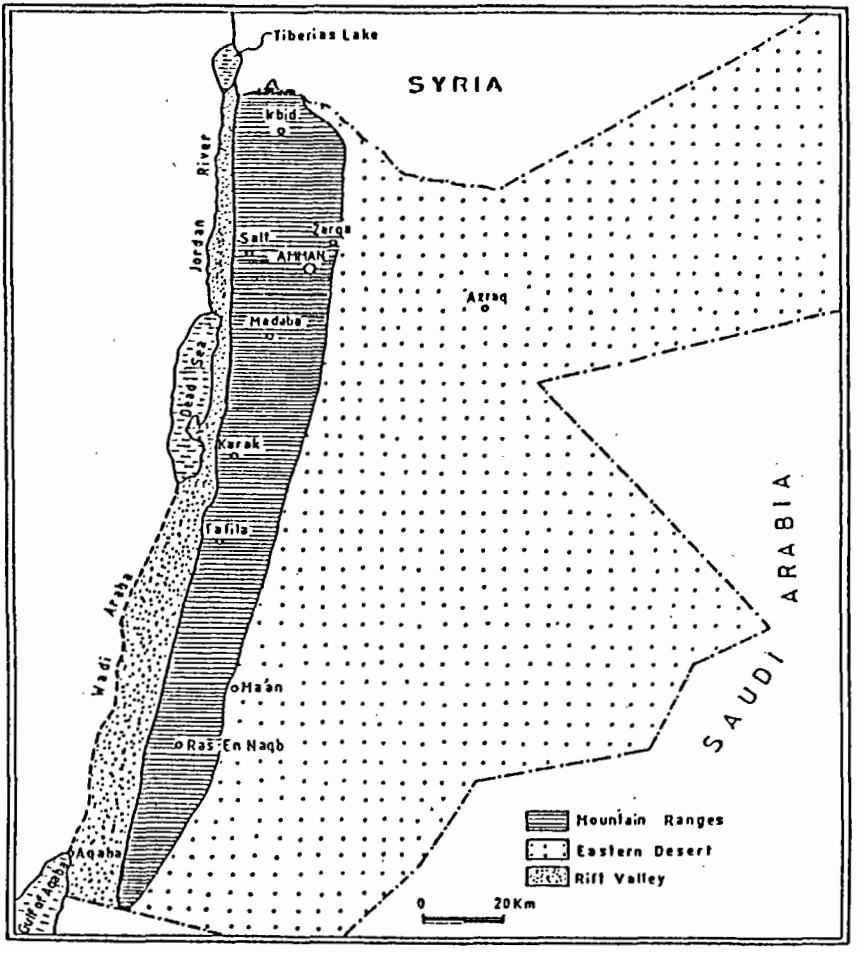
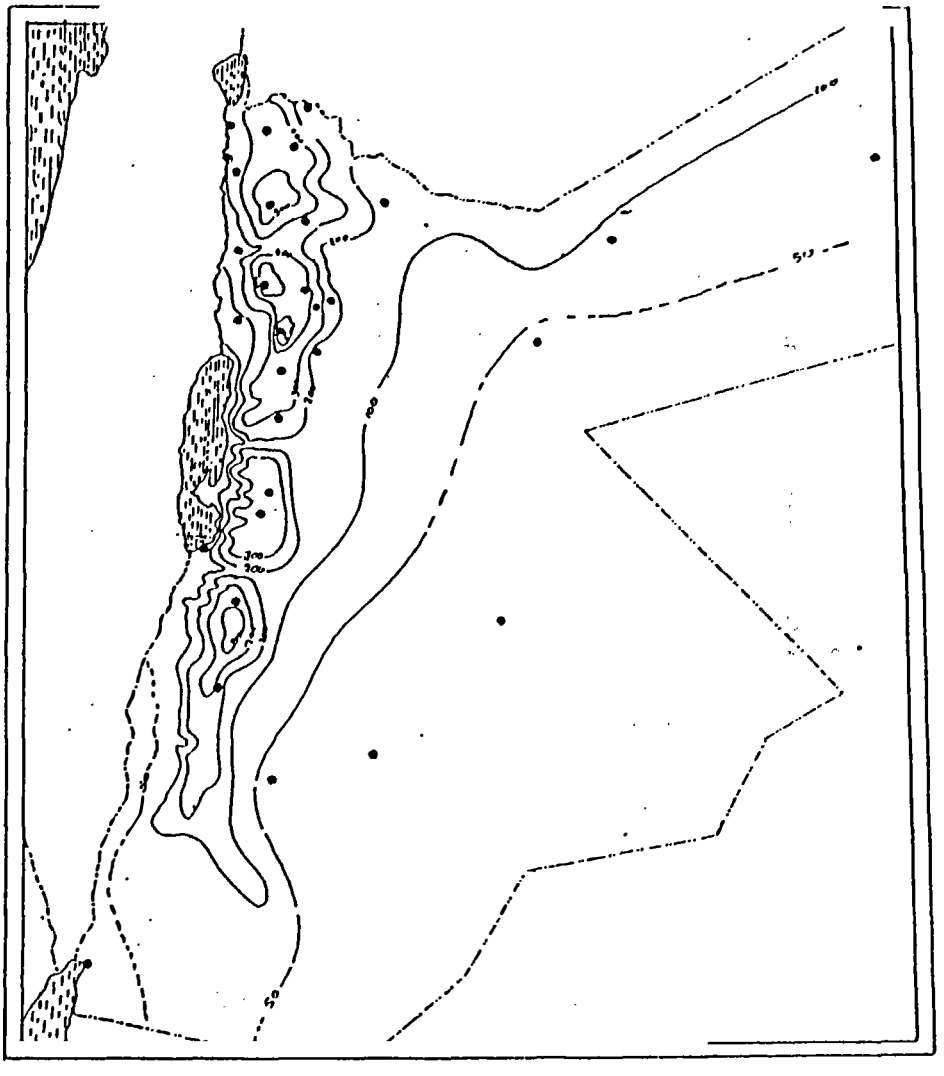


Fig. 2.1. Showing View of Wadi AL-Mujeb. The top part is a Mediterranean region, the middle is Irano-Turanian and the bottom is Tropical.

Map 2.2. Mean Annual rainfall in Jordan during the period 1966-1980 (AL-Eisawi 1983).



2.4. Temperature

The temperature is highly affected by the topography and the latitude of the different parts by which notable variations are recorded. The mean annual minimum temperature for the period between 1966-80 ranged between 5°C in Ash-Sharah mountains, and 20°C in Aqaba **(Map 2.3)**.

The mean annual maximum temperature ranged also between 30°C in Wadi Araba and 20°C in the mountain ranges **(Map 2.4)**.

These values vary considerably from year to year and even from season to season especially if we consider that the temperature may drop to below zero in the coldest month with frost formation in some places. It also may rise up in the hottest month reaching 50°C in some places like the Rift Valley.

It can be said that the temperature correlates quite well in Jordan with the amounts of rainfall, when the rainfall increases the temperature decreases in the same direction and the reverse is true.

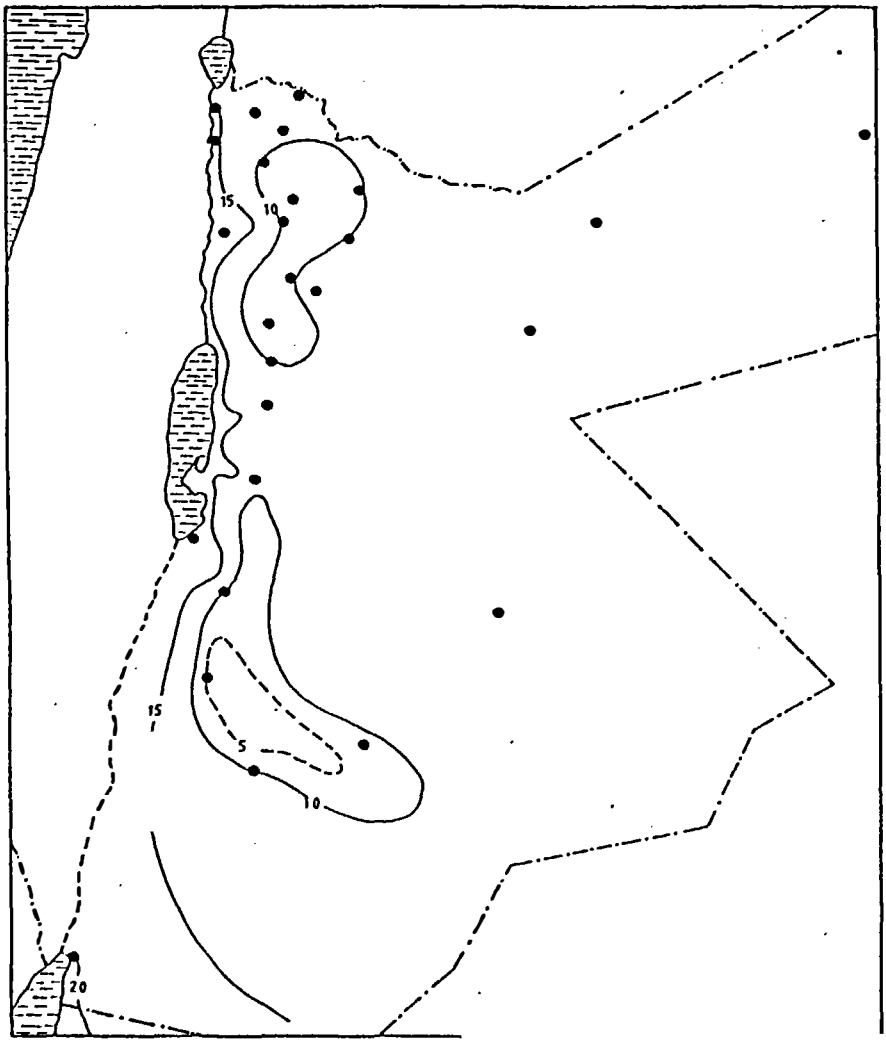
2.5. Soil

There is no doubt about the importance of the edaphic factors, especially the soil type and the soil texture in relation to the vegetation type and the association structure on the different soils.

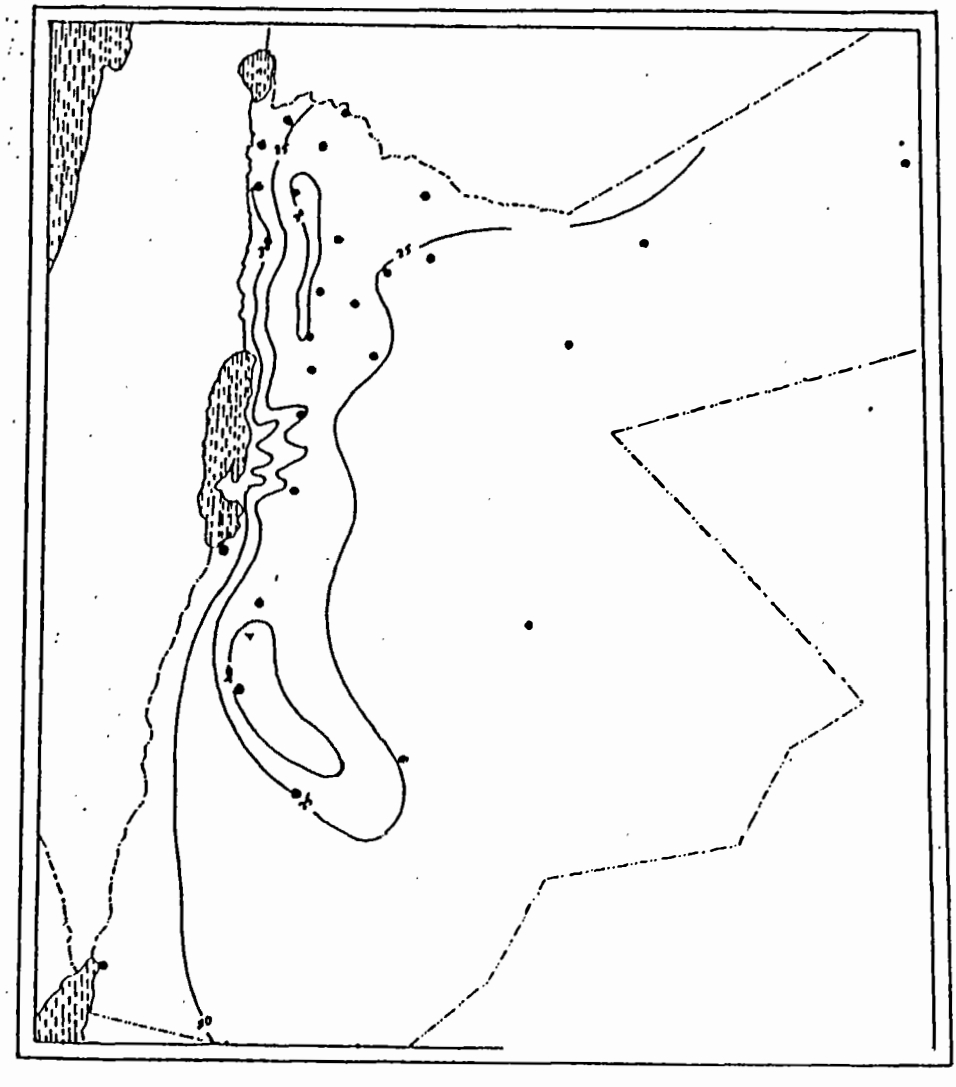
The soils in Jordan were studied and classified by several workers. There are differences in the methods of classification of the soil according to the different schools and methods used in this field; **MOORMANN** (1959), **ZOHARY** (1962), **NEDECO-DAR AL-HANDASAH** (1969), **HARRIS** (1971) and **BENDER** (1975).

However, the soils in Jordan do not show mature profile except in some places of the Mediterranean region and under the forest vegetation, where the best profile is found. It is made of horizons A & C, with some litter and organic matter on the floor of the forest. Other than that the soil is only represented by C horizon or even just the parental rock and that is mainly due to poor vegetation and continuous erosion.

Map 2.3. Mean Annual minimum temperature in Jordan during the period 1966-1980 (AL-Eisawi 1983).



Map 2.4. Mean Annual maximum temperature in Jordan during the period 1966-1980 (AL-Eisawi 1983).



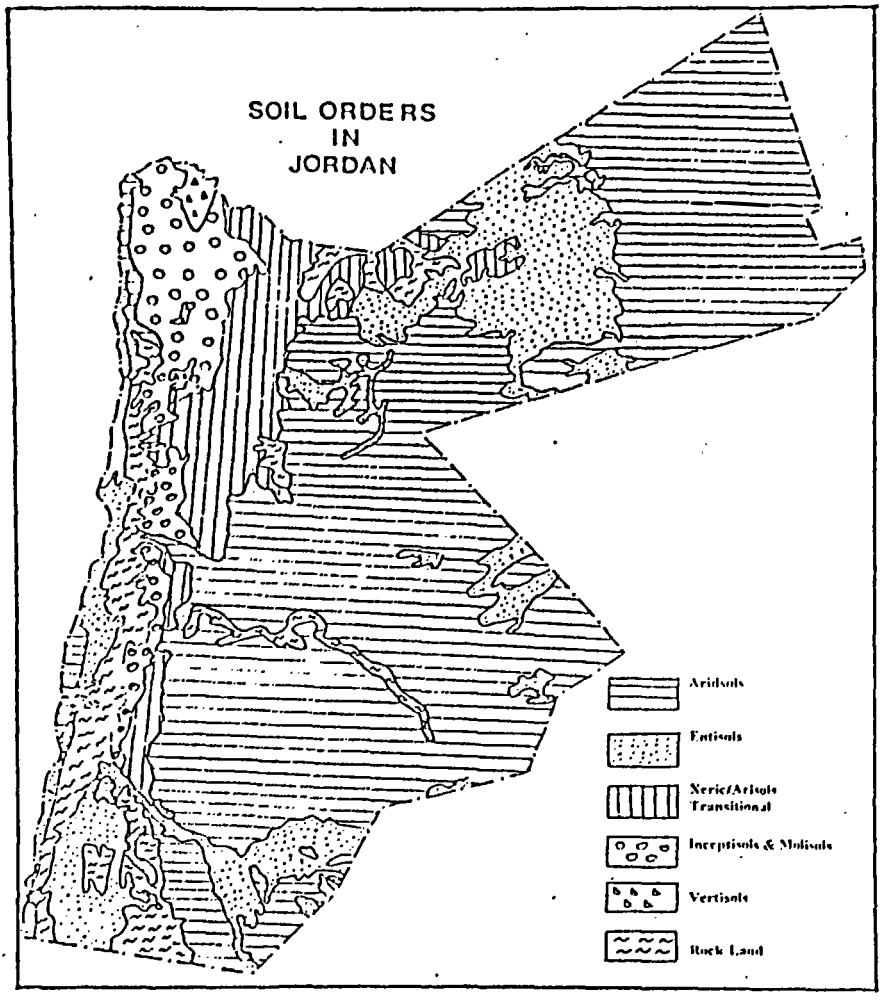
The soils in Jordan often show enormous variations within a very limited area, which in turn affect the vegetation accordingly.

The most fertile soil types in Jordan are the Terra Rossa and the Rendzina Series or what is equal to the Red and yellow Mediterranean soil, which are used for cultivation and support the best natural vegetation in the country. These types of soil usually occur under the maximum amount of rainfall and the least mean annual minimum and maximum temperatures.

The loess and the calcareous are dominant in the Irano-Turanian region while the sandy, the saline and the hammada soils are dominant in the desert region. These soil types are considered to be poor and well correlated with poor vegetation and with a low amount of precipitation and high temperature.

Recently, a final survey and classification of the soil in Jordan was finished the results of which are shown in **(Map 2.5)**.

Map 2.5. Showing soil orders in Jordan.



3. BIOGEOGRAPHICAL REGIONS

3.1. Bioclimatic regions

3.2. Vegetation regions

3.2.1. Mediterranean region

3.2.2. Irano-Turanian

3.2.3. Saharo-Arabian

3.2.4. Sudanian (Tropical)

3.1. Bioclimatic Regions (Biogeographical Regions)

Jordan has been subdivided into different bioclimatic or biogeographical regions according to the workers' points of view. However, most of these studies were not based on the analysis of climatic data; **KASAPLIGIL** (1956), **HUNTING TECHNICAL SERVICES LIMITED** (1956), **ZOHARY** (1962), **POORE & ROBERTSON** (1964), **BESKOK** (1971), The League of Arab States (**ARAB ORGANIZATION FOR AGRICULTURAL DEVELOPMENT** (1976), **BOULOS & LAHHAM** (1975) and **MADANY** (1978). **LONG** (1957) classified Jordan into eight bioclimatic regions (**Fig. 3.1**), with a map of distribution for these regions (**Map 3.1**).

Based on the rain distribution during the seasons of the year, the whole of Jordan is considered to be of the Mediterranean type because the rainfall is mainly in the Winter and the Spring WSpSA.

In this study, analysis similar to that done by **LONG** (1957) is presented for 31 stations during the period of 1966-80 (**Table 3.1**). This analysis was made with the help of Mr. I. ATAWI, Meteorological Department, Amman. The method used is based on Emberger quotient (**EMBERGER**, 1955).

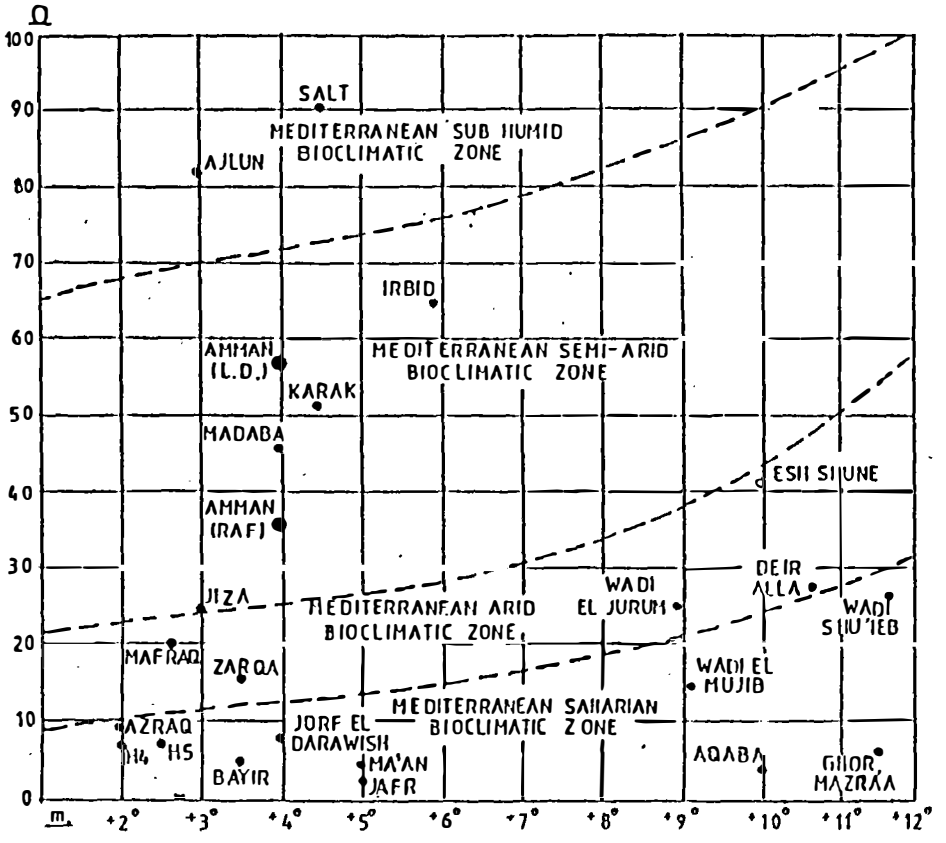
$$Q = \frac{P}{(M+m)/2 \times (M-m)} \times 1000$$

where:
P: is the mean annual rainfall of the site.
M: is the mean maximum temperature of the hottest month.
m: is the mean minimum temperature of the coldest month.
M + m /2: is the mean of extreme temperature.
M–m: represents a value proportion to evaporation.
The values of **Q** are plotted against m. (**Fig. 3.2**).
The distribution of the resulting bioclimatic zones are shown in (**Map 3.2**).

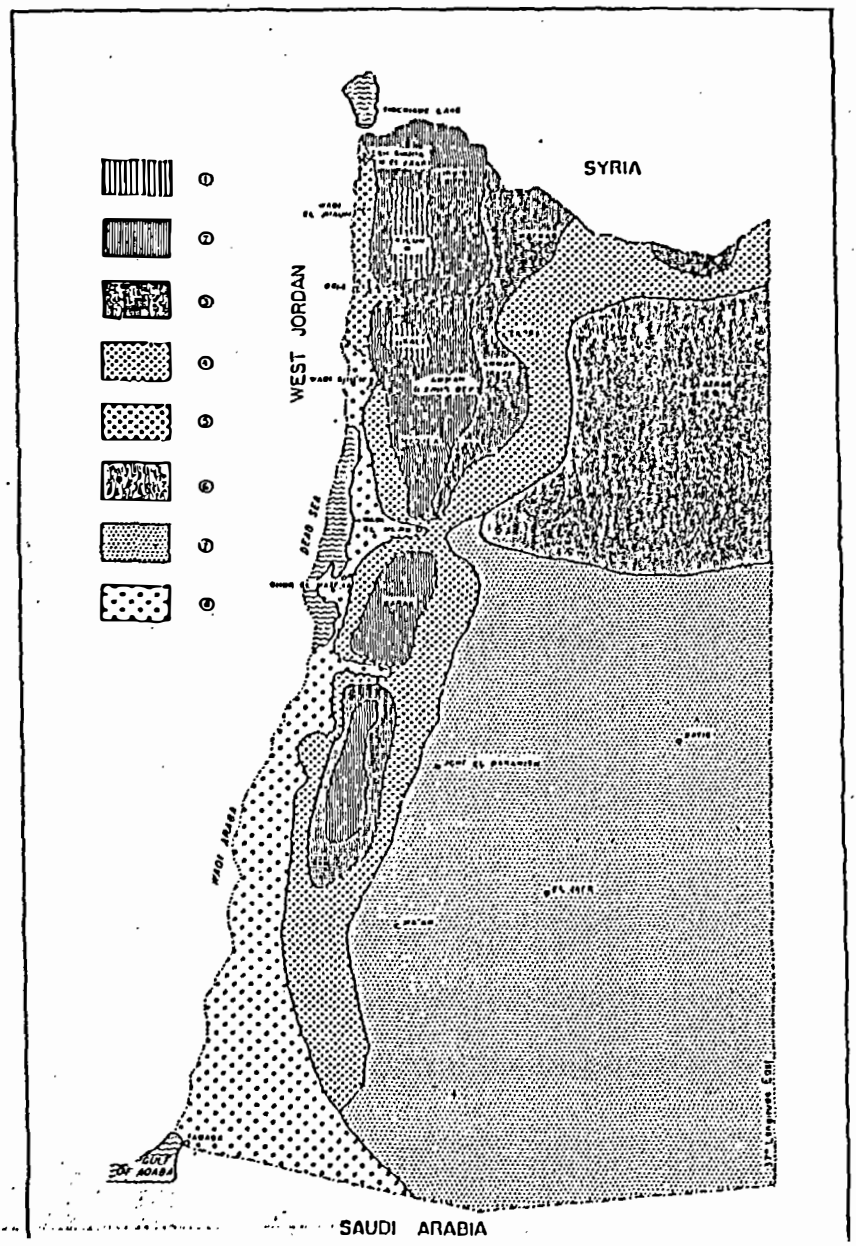
Table 3.1: Showing meteorological stations:

Station	P	M	m	M + m	M– m	Q
Baqura Nursery	379.8	37.0	8.6	295.8	28.4	45.21
Shuneh North	348.5	36.5	7.8	295.15	28.7	41.14
Wadi Yabis	292.0	37.9	7.2	295.55	30.7	32.18
Dair 'Alla	289.0	38.5	10.8	297.65	27.7	35.1
Ghor Safi	73.3	40.1	10.5	298.3	29.6	8.3
Aqaba Airport	36.9	39.2	8.7	296.95	30.5	4.48
Aqaba Port	35.3	37.2	11.6	297.4	25.6	4.64
Irbid Nursery	495.9	30.6	4.4	290.5	26.2	64.18
Ramtha	219.9	32.1	2.9	290.5	29.2	25.92
Taiyiba	488.1	33.7	6.4	293.1	27.3	61.0
Ras Muneef	519.4	26.9	2.4	287.65	24.5	73.7
Baka'a	364.3	31.6	4.0	290.8	27.6	45.4
Jord. Univ. Jubaiha	474.2	28.6	2.2	288.4	26.4	62.28
Amm. civil Airport	290.1	31.8	2.7	290.25	29.1	34.34
Amm. Rom. Theater	410.7	32.8	3.9	291.35	28.9	48.77
Na'ur Trans. St	502.5	29.7	2.9	289.3	26.8	64.81
Madaba	368.1	30.5	2.9	289.7	27.6	46.0
Wadi Walah	269.5	33.7	4.6	292.15	29.1	31.7
Er-Rabbah	344.3	29.8	3.5	289.65	26.3	45.2
AL-Hassan Agr. Sta.	298.9	29.3	1.8	288.55	27.5	37.67
Shaubak	298.3	25.6	–1.4	285.1	27.0	38.75
AL-Qurein	199.2	27.7	0.6	287.15	27.1	25.6
H4	76.4	37.1	1.9	292.5	35.2	7.42
Mafraq	164.0	32.3	1.8	290.1	30.4	18.6
H5	86.5	36.0	2.3	292.15	33.7	8.79
Wadi Dhuleil	147.6	34.4	1.7	291.05	32.7	15.51
Zarka Refinery	148.0	33.2	3.0	291.1	30.2	16.8
Azraq	69.9	36.3	2.6	292.45	33.7	7.1
AL-Jiza	189.4	31.5	0.7	289.1	30.8	21.7
Ma'an Airport	43.8	33.9	1.5	290.7	32.4	4.65
Jafr	37.9	35.4	–0.2	290.6	35.6	3.66

Fig. 3.1. Distribution of 24 stations of East Jordan regarding their Q (quotient pluviothermique of Emberger) and m (mean of the minimal temperatures of the coldest month) (**LONG,** 1957).



Map 3.1. Showing eight bioclimatological subdivisions in Jordan (**LONG,** 1957).



Legend to Fig. 3.2. Showing nine bioclimatic subdivisions are considered as follows:

1) Sub-humid Mediterranean bioclimate, warm and cool varieties (Ras Muneef, Ajloun).

2) Semi-arid Mediterranean bioclimate, warm variety (Irbid, Amman, Madaba, Taybeh and Baka'a).

3) Semi-arid Mediterranean bioclimate, cool variety (Shaubak).

4) Arid Mediterranean bioclimate, cool variety (Mafraq, AL-Jiza, AL-Qurein and Wadi-Dhuleil).

5) Arid Mediterranean bioclimate, warm variety (Zarka and Ramtha) falls at the border line between cool and warm.

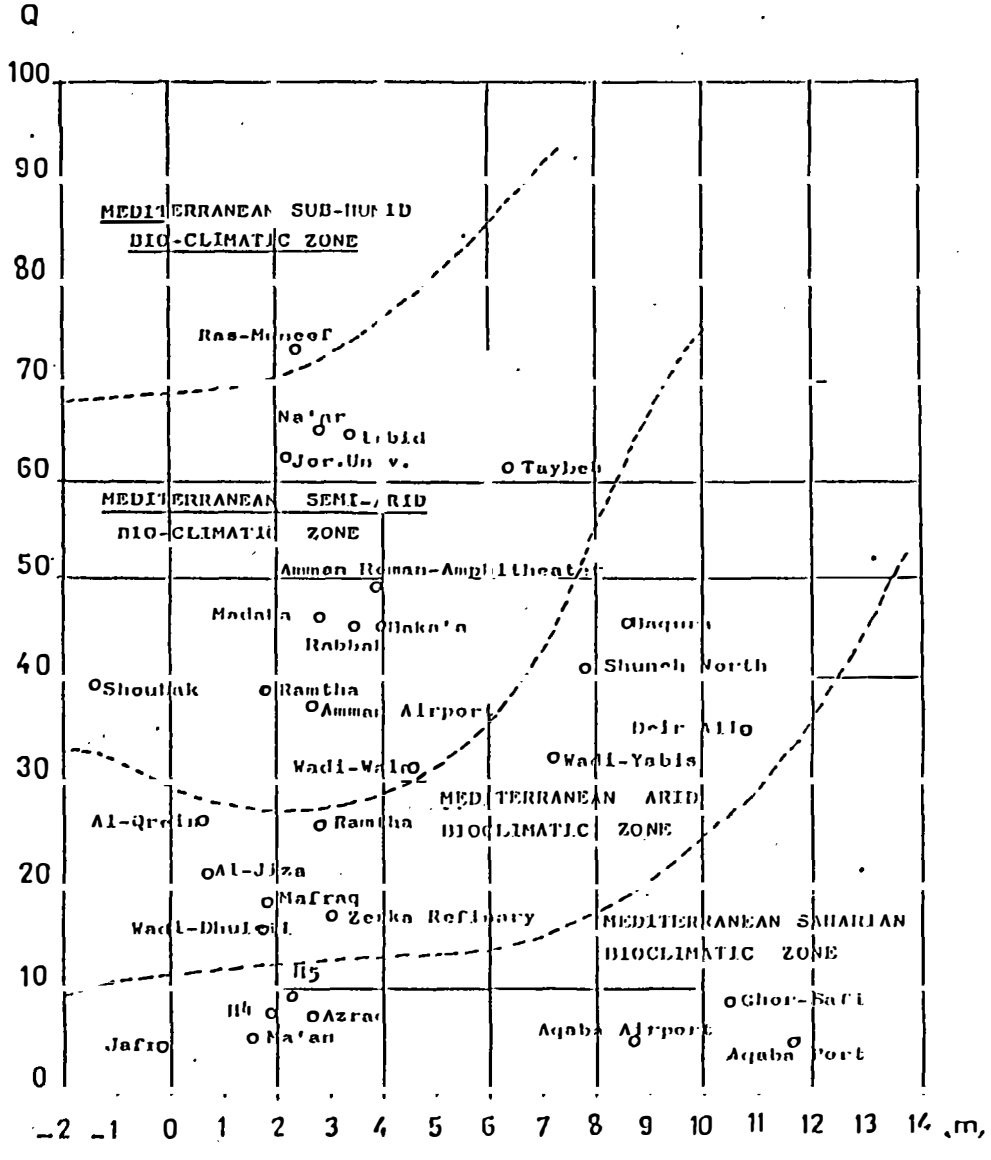
6) Arid Mediterranean bioclimate, very warm variety (Dair 'Alla, AL-Baqura, Shuneh North, and Wadi-Yabis) falls at the border of the line between warm and very warm.

7) Saharan Mediterranean bioclimate, cool variety (AL-Jafr, H4, Ma'an, H5 and AL-Azraq).

8) Saharan Mediterranean bioclimate, warm variety (Belt of land with an average width of 20 km. along the Eastern hills to the East).

9) Saharan Mediterranean bioclimate, very warm variety (Ghor Safi, Wadi-Araba and Aqaba area).

Fig. 3.2. Distribution of 31 stations of East Jordan regarding their Q (quotient pluviothermique of Emberger) and m (mean of the minimal temperatures of the coldest month) (**AL-EISAWI,** 1983).



Legend to Map 3.2. Showing Bioclimatic Regions of Jordan:

1) Sub-humid Mediterranean bioclimatic warm and cool varieties (Ras Muneef, Ajloun).

2) Semi-arid Mediterranean bioclimatic, warm variety (Irbid, Amman, Madaba, Taybeh and Baka'a).

3) Semi-arid Mediterranean bioclimate, cool variety (Shaubak).

4) Arid Mediterranean bioclimate, cool variety (Mafraq, AL-Jiza, AL-Qurein and Wadi Dhuleil).

5) Arid Mediterranean bioclimate, warm variety (Zarka and Ramtha, falls at the border line between cool and warm).

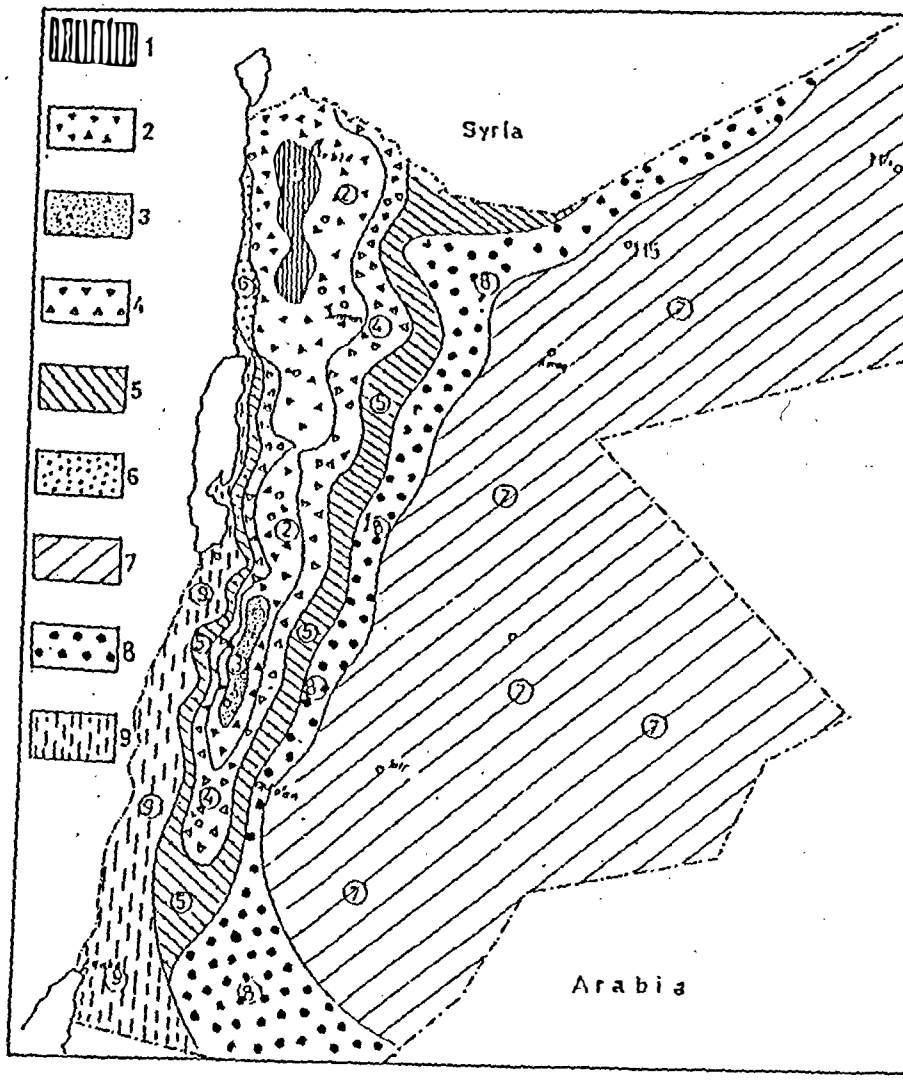
6) Arid Mediterranean bioclimate, very warm variety (Dair 'Alla, AL-Baqura, Shuneh North, and Wadi Yabis, falls at the border of the line between warm and very warm.

7) Saharan Mediterranean bioclimate, cool variety (AL-Jafr, H4 (Ruweished), Ma'an, H5 (Safawi) and Azraq).

8) Saharan Mediterranean bioclimate, warm variety (Belt of land with an average width of 20 km along the Eastern Hills to the East).

9) Saharan Mediterranean bioclimate, very warm variety (Ghor Safi, Wadi Araba and Aqaba area).

Map 3.2. Showing nine bioclimatological subdivisions in Jordan (**AL-EISAWI,** 1985).



The results of this analysis are almost similar to those of **LONG** except:

1) A new sub-division of the semi-arid Mediterranean cool variety is found and exists in the region of Shaubak and Tafila which has a (Q) value ranging between 30-70 and (m) value of less than 3°C.

2) The whole Eastern desert falls under one sub-division as Saharan Mediterranean-cool variety bioclimate, while in Long.'s analysis it is divided into two sub-divisions:

a) Saharan Mediterranean bioclimate-cool variety which included H4, H5 and Azraq.

b) Saharan Mediterranean bioclimate-warm variety in the area of Ma'an, Jorf El-Darawish, Bayir and Jafr.

These nine bioclimatic sub-divisions fall under four main regions:

3.1.1. Sub-humid Mediterranean bioclimate

The quotient (Q) according to Emberger lies between 70 and 100. The mean minimum temperature (m) of the coldest month (January) varies between +2°C and 3°C, and a warm variety above 3°C. The mean maximum temperature (M) of the hottest month (August) is almost 27°C which is a characteristic for a moderately warm summer.

The map (**Map 3.2**) shows that this sub-division exists only in a relatively small part of the country, Salt and Ajloun.

3.1.2. Semi-arid Mediterranean bioclimate

The (Q) value according to Emberger lies approximately between 30 and 70. The average minimum temperature (m) during the coldest month (January) varies approximately between -1°C and +7°C, it indicates a cool variety (m between -1 and 3°C) and a warm variety (m between +3°C and 7°C) of the semi-arid Mediterranean bioclimate. The average maximum temperature (M) during the hottest month (August) ranges between 26C°-33°C. The region is slightly warmer than sub-humid zone.

The places included under this region are: Amman, Irbid, Madaba, Taybeh, Baka'a, Shaubak and Tafila (**Figs. 3.1 & 3.2**).

This region includes the rest of the mountain ranges.

3.1.3. Arid Mediterranean bioclimate

The value (Q) according to Emberger lies approximately between 10 and 30 in the cool and warm varieties and between 20 and 50 in the very warm variety. The mean minimum temperature (m) of the coldest month (January) varies approximately between 1°C and 11°C. This wide range of variation makes it possible to observe a large number of bioclimatic varieties such as a cool variety (m between 1°C and 3°C), a warm variety (m between 3°C and 7°C) and a very warm variety (m between 7°C and 11°C).

The mean maximum temperature (M) of the hottest month (August) varies between approximately 28°C and 39°C. The summer is definitely warmer in the arid zone than the preceding ones.

The varieties of this arid Mediterranean regions are shown in **Figs. 3.1 & 3.2**. AL-Qurein, AL-Jiza, Wadi Dhuleil and AL-Mafraq in the cool variety; Ramtha and Zarka in the warm variety, and Baqura North, Dair 'Alla and Wadi Yabis in the very warm variety.

3.1.4. Saharan Mediterranean bioclimate

The (Q) value according to Emberger lies approximately between 2 and 15 for the cool and warm varieties and between 2 and 30 for the very warm variety. The mean minimum temperature ranges between -1°C and +3°C for the cool variety and between +8°C and +12°C for the very warm variety. It is presumed that the warm variety falls between 3°C and 7°C.

The maximum temperature (M) of the hottest month (August) ranges between 35°C and 40°C.

The summer in this region is very warm while the winter is mild. This region has a cool variety which includes almost all the Eastern desert, H4, H5, Azraq, Jafr and Ma'an; a very warm variety which exists in the Rift

Valley South of Dair 'Alla; and a warm variety which forms a strip of about 20 km. in width and separates the cool Saharan region from the warm arid zone from North to South.

3.2. Vegetation Regions

From the previous climatic subdivisions and from the vegetation characteristics of these divisions and according to **ZOHARY** (1973) delimitations of the vegetation regions in the Middle East, four regions of vegetation are found:

1. The Mediterranean region.
2. The Irano-Turanian region.
3. The Saharo-Arabian region.
4. The Sudanian region.

These regions are shown in the map of distribution **(Map 3.3)** and may represent the climatic subdivision as follows: The Mediterranean, the Semi-arid Mediterranean-warm variety and the Semi-arid Mediterranean-cool variety **(zones 1,2 and 3 in Map. 3.2)**.

The Irano-Turanian or the steppes region which includes the Arid-Mediterranean bioclimate; cool, warm and very warm varieties **(zones 4, 5 and 6 in Map 3.2)**.

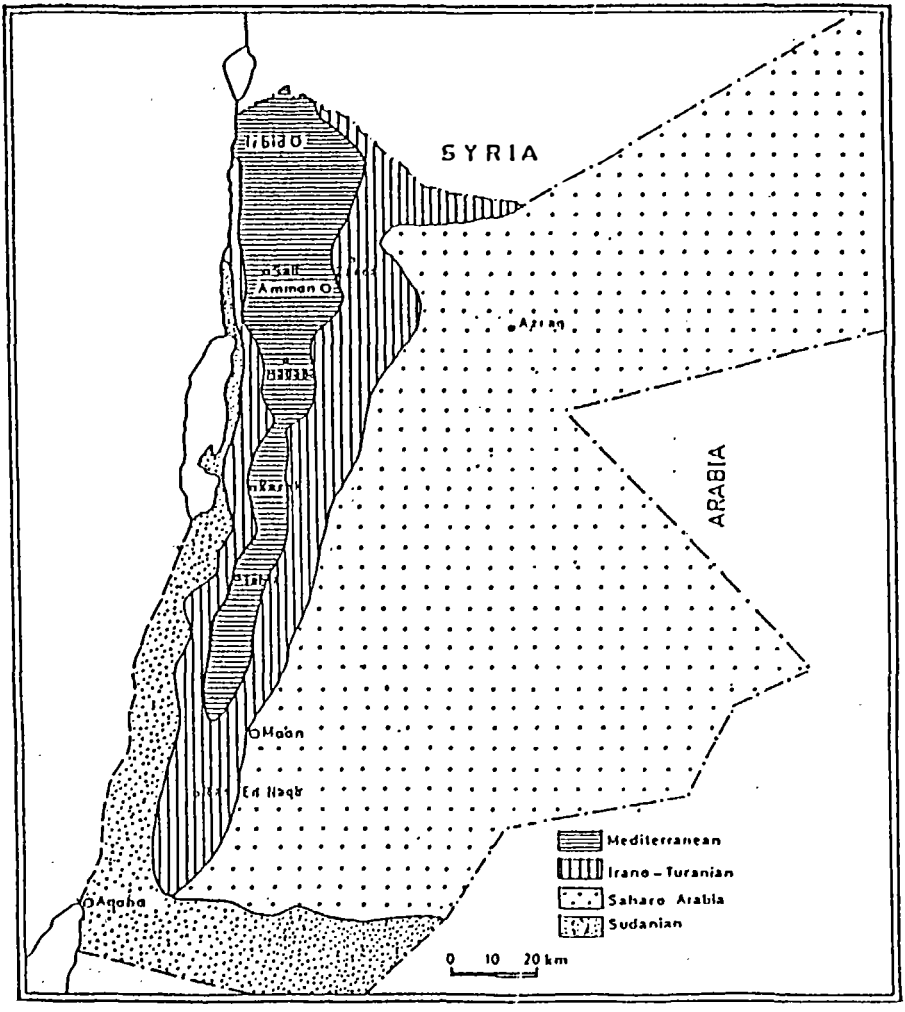
The Saharo-Arabian which includes the Saharan-Mediterranean bioclimate: cool and warm varieties **(zones 7 and 8 in Map 3.2)**.

The Sudanian region which includes the Saharan-Mediterranean bioclimate: cool and warm varieties **(zones 7 and 8 in Map 3.2)**.

The Sudanian region which includes the Saharan-Mediterranean bioclimate-very warm variety only **(zone 9 in Map 3.2)**.

The factors and the characteristics determining the distribution of the four vegetational regions are the following **(Map 3.3)**.

Map 3.3. Showing four biogeographical regions in Jordan (**AL-EISAWI 1983**).



3.2.1. The Mediterranean region

This region in Jordan is characterised by having the best rainfall (ranges from 400-600 mm/year), the most fertile soil, the highest altitude (900-1700 m), the least summer temperature (rarely exceed 30°C), and finally the best vegetation.

This region includes almost all the mountain ranges which extend from the North in Irbid down to the South in Ras An-Naqab with a mean annual rainfall usually over 300 mm. The soil is of the types Terra Rossa and Rendzina which are the richest in the country and support the best vegetation especially the forest climax of ***Pinus halepensis, Quercus coccifera, Q. ithaburensis, Ceratonia siliqua,*** and ***Pistacia spp.***

3.2.2. The Irano-Turanian region

This region in Jordan is characterised by rainfall ranges from 150-300 mm/year, poor soil, altitude ranges from 400-700 m, the temperature is more than the previous region, it might go up to 35-40°C during the hot season.

It surrounds all the Mediterranean region except the North, and forms a narrow strip in some places which may interrupt the Mediterranean region in some of the depressions such as Wadi Mujeb **(Fig. 2.1)**and Wadi AL-Hasa. The mean amount of rainfall in this region is usually over 150 mm. The soil is mostly poor, eroded and mostly of the calcareous or loess types. The vegetation is a timber less land (no trees) with mostly shrubs and bushes, like those of ***Retama raetam, Ziziphus lotus, Artemisia herba-alba, Noaea mucronata, Anabasis syriaca.***

3.2.3. The Saharo-Arabian region

In Jordan this region is called Badia, since it has different set of characters other than those of typical deserts known anywhere else. In typical deserts there are lots of sand dunes, while in Jordan desert, the land is clayey and covered by gravels or pebbles. Accordingly the parts of the Badia are called Hammada or Hammad or Harra. Usually the Harra is covered by black basaltic pebbles, while Hammada is covered by gravels.

This area is characterised by having very cold winter and usually very dry, hot summer, temperature may exceed 40°C in the hot season, while it might go down up to -10°C during the coldest days of the year. The soil is very poor and mostly of the type Hammada, saline, sandy-loam or mud flats in some parts. Rainfall ranges from 50-100 mm/year, the mean annual rainfall is almost 50 mm. Altitude is usually about 600-700 rarely exceeds that in some parts. This area comprises the majority of Jordan and borders the Irano-Turanian on the East forming about 85% of the total area of Jordan.

The vegetation is mostly composed of fleshy plants which can resist the hot conditions. Animals mostly reptiles, some birds, rodents and some mammals. The vegetation is very poor and sometimes non-existent, especially in the mud flats. Most of the plant cover is restricted to the watershed in the wadies where enough soil moisture is available to hold some vegetation. The most common species are ***Artemisia herba-alba, Achillea fragrantissima, Phlomis, Astragalus, Stipa, Trigonella.***

3.2.4. The Sudanian region

This area is restricted to the hottest part of the country. It covers Wadi Rum, Wadi Araba, Dead Sea area and extends to the North until almost Dair 'Alla. This region is characterised by having usually warm winter and very hot summer, the temperature ranges from 15-45°C. It might go beyond these limits in some days of the year. It is also unique in having the lowest point on Earth where it reaches about -400 m at the Dead Sea level. The rainfall ranges from 50-100 mm/year. Soil is mostly alluvial, saline, sandy or sand dunes, hammada, some granite fragments and Lisan marls.

It is called tropical or Sudanian penetration because it has some physical and biological characters similar to those occurring in Sudan. The umbrella like ***Acacia*** trees are similar to those growing in Sudan and Ethiopia.

The vegetation here is related to tropical varieties like those of ***Acacia spp., Balanites aegyptiaca, Calotropis procera, Maerua crassifolia, Salvadora persica, Haloxylon persicum, Ochradenus baccatus, Panicum turgidum*** and others.

4. VEGETATION

4.1. Vegetation types

- 4.1.1. Pine forest
- 4.1.2. Evergreen oak forest
- 4.1.3. Deciduous oak forest
- 4.1.4. Juniper forest
- 4.1.5. Mixed forest
- 4.1.6. Mediterranean non-forest vegetation
- 4.1.7. Steppe vegetation
- 4.1.8. Hammada vegetation
- 4.1.9. Saline (Halophytic) vegetation
- 4.1.10. Tropical vegetation
- 4.1.11. Sand dune vegetation
- 4.1.12. Acacia and Sudanian rocky vegetation
- 4.1.13. Water (Hydrophytic) vegetation
- 4.1.14. Mud flats (Qaa' or Bajada)

Introduction

Jordan and Palestine have received special attention of early explorers due the old history and religious importance. Early studies were made during the nineteenth century and the beginning of this century such as: **LOWNE**(1886 & 1867); **AARONSOHN** (1909 a, & b; 1910 & 1913); **AARONSOHN & OPPENHEIMER** (1931); **EIG** (1927- 1946); **BOYKO** (1949), **FEINBRUN & ZOHARY** (1942 & 1955), **ZOHARY** (1940 b;1940 c; 1944; 1955; 1960; 1962; 1973 & 1982).

The best of **ZOHARY'S** were those of (1962& 1973) when he talked about Palestine and Jordan and then later talked about the Middle East in general. Some other studies were made by **ZOHARY & ORSHANSKY** (1949 &1951); **ZOHARY & ORSHAN** (1994 & 1956); **DANIN** (1966; 1970; 1971; 1983; 1986 & 1988); **HALEVY & ORSHAN** (1972). Jordan in particular has received special attention to study the range land and forestry by some international experts coming through UN organization especially **FAO** where they submitted reports to the Hashemite Kingdom of Jordan. Most of these studies are of the survey type, and were based on short visits such as: **KASAPLIGIL** (1956), **LONG** (1957), **HUNTING TECHNICAL SERVICES LIMITED** (1956), **POORE & ROBERTSON** (1964), **CASHMORE** (1952); **CALAMBERT** (1972).

Within the past twenty years active research in Jordan have taken place to study the vegetation of specific parts of Jordan as well as studies related to forestry and desertification, such as **ABBAS** (1989); **ABED & AL-EISAWI** (1994); **AL-EISAWI** (1983; 1985 & 1994); **AL-EISAWI & HATOUGH** (1987); **AL-JUNDI** (1972); **AL-SYOOF** (1988); **BARHAM** (1979 & 1986); **HATOUGH et al.** (1986); **SAAD-EDDIN** (1983) and **SHARKAS** (1994).

Within the past ten years a group of German and Austrian scientists started to work on Southern part of Jordan especially and published paper about the vegetation of that area including Petra and Wadi Araba such as: **BACHMANN & HAUOTMANN** (1984); (1993); **BAIERLE et al.** (1989a); **BARBERO & QUEZEL** (1979); **FREY & KÜRSCHNER** (1983a & 1989a,b); **FREY & PROBST** (1977); **GEBEL** (1986 & 1990); **HAUPTMANN** (1986); **JENNEY et al.** (1990); **KÜNNE &**

WANKE (1990); **KÜRSCHNER** (1986a); **SUKOPP** (1990); **WINTER** (1990).

Important work on similar dry habitat of neighbouring countries was made namely: **BARBERO & QUEZEL** (1979); **DAVIS** (1951); **GUEST** (1986); **PABOT** (1980), **POORE & ROBERTSON** (1964); **THALEN** (1979); **TOMASELLI** (1981); **WEINERT et al.** (1981).

Recently, there have been some real solid investigations into the ecology and the vegetation of Jordan trying to use recent aerial photographs supported by extensive field trips for mapping and definition of the structure of plant associations, to recognize the vegetation types and the geographical regions.

In this report the vegetation of Jordan will be discussed in the light of the previous work, and related to information collected from experience through observations recorded during extensive field trips to collect and study the flora of Jordan for the past 24 years.

Floristic notes with some remarks on local parts of Jordan have been published within the last 10 years which are of great help in giving some information about the vegetation composition in these particular places, **AL-EISAWI** (1977; 1982; 1984; 1986a,b,c; 1988; 1989; 1990 & 1994), **AL-EISAWI et al.** (1995a,b) **BOULOS & AL-EISAWI** (1977), **BOULOS & JALLAD** (1977), **BOULOS & LAHHAM** (1977), **EL-OQLA & LAHHAM** (1986); **JALLAD** (1975), **LAHHAM** (1975); **KISWANI** (1994); **OMAR** (1994); **ORAN** (1991, 1994 & 1995); **ORAN et al.** (1995); **ORAN & AL-EISAWI** (1995).

4.1. The Vegetation Types

The vegetation classification of Jordan has been treated and discussed differently by the previous workers. **LONG** (1956) considered two main groups: 1) Forests and 2) Pasture types; with 38 different associations and about 10 or more sub associations. **THE HUNTING TECHNICAL SERVICES LIMITED** (1956) and **POORE & ROBERTSON** (1964) considered five types: 1) Grass land 2) Brush 3) Bare Rock 4) Forest 5) Bare Ground, with many subdivisions under them. **KASAPLIGIL** (1956) considered five types as:

1) Secondary Degraded Forest.
2) Coniferous Forest.
3) Broad Leafed.
4) Grass lands.
5) Other Main Vegetation Types.

ZOHARY (1962) recognized many classes and types of vegetation in relation to their territories. **AL-JUNDI** (1977) represented the vegetation of Jordan through six sectors passing across the country from the West to the East. His work was in fact copied from **KASAPLIGIL. ABU-HOWAYEJ** (1973) gave the vegetation distribution in the Agricultural Atlas of Jordan, taken from **THE HUNTING TECHNICAL SERVICES LIMITED** and **POORE & ROBERTSON**.

In this study the vegetation types will be discussed in relation to their vegetation regions considering only the natural vegetation without dealing with the cultivated land. The following recognized types are cited on a map of distribution **(Map 4.1)**.

4.1.1. Pine forest

Typical Mediterranean vegetation forms the best forests in Jordan and reaches a climax in some places, with the dominant trees of Aleppo pine ***(Pinus halepensis)*** up to 15 meters **(Figs. 4.1 & 4.2)**. This forest vegetation usually occurs naturally on high altitudes, mostly over than 700m. and where Rendzina and calcareous soils are present. In some places the pine trees are replaced by ***Quercus coccifera*** as a result of the degradation of the primary vegetation, forming a secondary succession.

Such type of forest trees usually have shallow root system. Therefore, they tend to fall down during season of heavy snow fall. In addition the wood is rather soft and the trees if do not fall down they tend to break. Great loss of trees of Aleppo pine forests occurred in the winter of 1992 when several times of heavy snow struck the mountainous regions. Also this forest is the most susceptible for fire due to the production of fairly large amounts of resin.

The natural occurrence of Aleppo pine forest is restricted to the Northern parts of Jordan only. Therefore, pine forest observed in Southern Jordan are man made.

Map 4.1. Showing 13 vegetation types in Jordan (AL-EISAWI 1983).

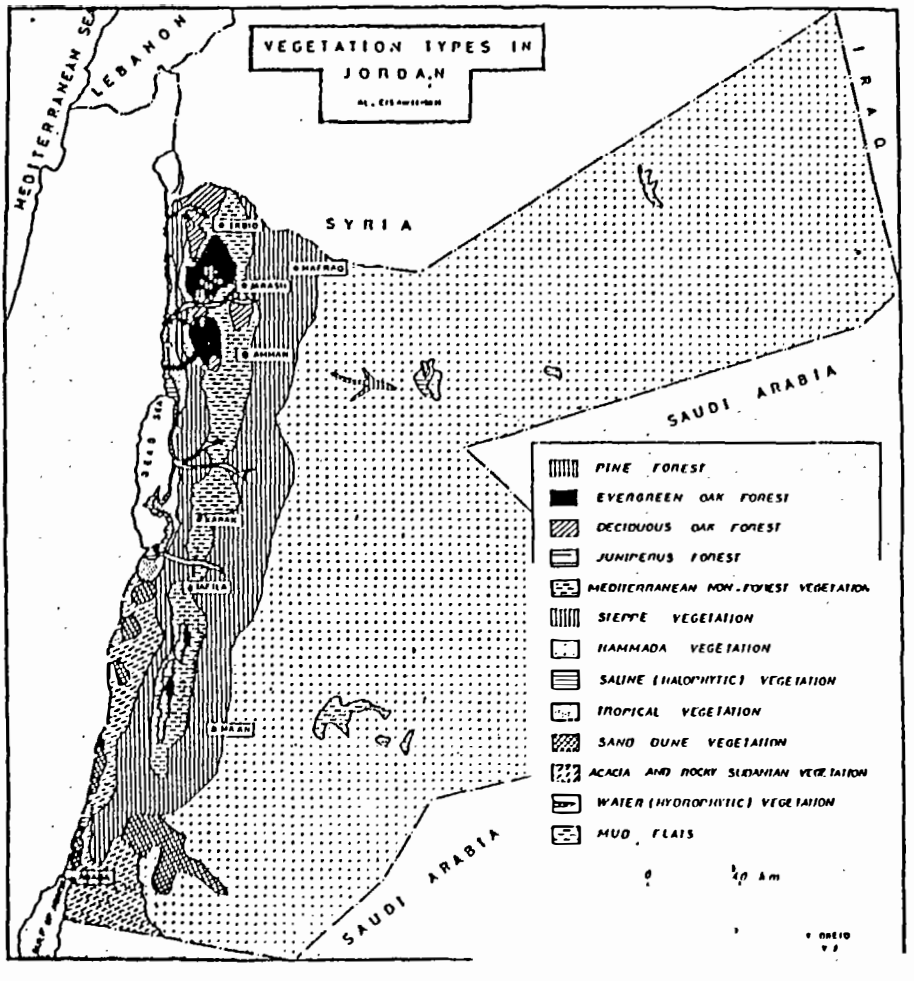


Fig. 4.1. Showing thick natural Aleppo pine forest ***Pinus halepensis***.

Fig. 4.2. Showing Pine forest stratification made of:
a. high trees of ***Pinus halepensis***, b. low trees or shrubs of ***Arbutus andrachne***, c. low shrubs of ***Calycotome villosa***, d. bushes and herbs of ***Cistus creticus***, ***C. salvifolius***, ***Fumana arabica***, different Orchid species especially ***Orchis anatolica*** and ***Ophrys fusca***, some grasses such as ***Dactylis glomerata*** and ***Poa bulbosa***.

The Ministry of Agriculture represented by the department of forestry is carrying out a programme or reforestation since 1950s. Most of the trees used for this reforestation project in the mountainous region are mostly Aleppo pine trees. The reason for this is the speedy growth of pine trees in comparison with oak trees. Thus often one can find Aleppo pine forest on red (Terra Rossa) soil, which is unnatural. This erroneous practice will not enable the natural vegetation elements growing under natural Aleppo pine forest on yellow soil to regenerate on red soil. This due to the fact that the needles of pine trees are acidic and the yellow soil is alkalinic which neutralizes the soil and enhances its characters. Contrary to that, when the acidic needles of pine trees fall onto the red acidic soil, the soil conditions will be worse and will not allow certain species to appear. Orchid species are the most affected by this phenomenon.

Localities:
Ajloun city, in the mountains opposite Ajloun castle, along the road between Sakib and 'Anjara; along the road between Jarash and Sakib, Dibbeen and Zai in As-Salt district.

Composition:
Four strata can be recognized in this type of vegetation.

Stratum 1. The high trees:
Pinus halepensis

Stratum 2. The low trees and shrubs:
Arbutus andrachne
Quercus calliprinos
Pistacia palaestina

Stratum 3. Low shrubs and bushes:
Calycotome villosa
Cistus villosus
Cistus salvifolius
Smilax aspera
and others.

Stratum 4. Herbaceous:
Fumana arabica
Thesium bergeri
Helianthemum lavandulaefolium

Most of the Orchids occur under such forest, for example:
Ophrys spp.
Lemodorum abortivum
Cephalanthera longifolia
Orchis anatolica

4.1.2. Evergreen oak forest

This vegetation is often classified as Mediterranean shrub land known as maquis or chaparral in other parts of the world (**Figs. 4.3, 4.4 & 4.5**).The dominant element in type is the evergreen oak forest ***Quercus coccifera,*** recognised by **ZOHARY** (1962& 1973) as ***Quercus calliprinos***. It comprises the major part of the forest vegetation in Jordan and occurs in the North, Middle and South, differing from other types which either occur in the North (Aleppo pine and deciduous oak forests) or the South of Jordan (Juniperus forests). This type of vegetation grows at high altitudes of more than 700m., and on red soil (Terra Rossa) of hard limestone parental rock, unless it is a secondary vegetation replacing Aleppo pine forest on calcareous or yellow (Rendzina) soil of soft limestone parental rock.

This vegetation type is being affected the most by human impact through the reduction of the forest into agricultural land, and through the cutting of trees for heating and coal production. Vast areas in Jordan show the remnants of such forests in the new growth of shoots from the lower parts of the trunks and the roots.

Fig. 4.3. Showing evergreen oak forest dominated by ***Quercus coccifera***.

Fig. 4.4. Showing Ajloun Castle surrounded by degraded evergreen oak forest ***Quercus coccifera*** due to human activity.

Fig. 4.5. Showing ***Quercus coccifera*** remnants of evergreen oak forest formation in Southern Jordan near AL-Hisha, Shaubak.

This vegetation, if protected, will be able to grow and re-establish itself to reach the climax and will be dominated by leading trees of about 6 meters in height. But if not, degradation will rapidly take place and most of the vegetation will be destroyed, being represented only by scattered shrubs and bushes.

The vegetation composition of this type of forest varies throughout the leading species including the evergreen oak ***Quercus coccifera*** which is the most important element, and on which the forest name is based. Although this vegetation is called evergreen, many of its components are deciduous like ***Pistacia palaestina, Pyrus syriaca*** and ***Crataegus azarolus.*** It is believed that most of the high lands of cultivated red soil in Jordan was once covered by this type of forest.

It is well known that the wild tree Kharroob ***Ceratonia siliqua*** occurs in Jordan as an element of deciduous oak forest association ***Quercus ithaburensis*** (*Senso lato*). In the spring of 1994 during my survey for the vegetation of Dana Reserve I was able to observe and to collect a herbarium specimen of ***Ceratonia siliqua*** growing naturally within the evergreen oak forest ***Quercus coccifera*** mixed with ***Juniperus phoenica*** on sand stone formation.

This is an odd discovery so far for the distribution of this species in Jordan.

Between Ajloun and Irbid in Zubia area and in particular in a place called Bergish the evergreen oak forest is mostly dominated by the leading species of ***Quercus coccifera*** followed by ***Phillyrea media.*** At lower altitude the evergreen oak becomes mixed with deciduous oak trees. In this case the second leading species of both forest types (deciduous and evergreen) will be also mixed and species of ***Pistacia palaestina, Ceratonia siliqua, Styrax officinalis*** and ***Phillyrea media*** can be found together.

Localities:

This forest type extends from Wadi Es-Sir near Amman almost up to Irbid in the North. It also occurs in the South in Bir AL-Ata'ta, Tafila district and AL-Hisha between Shaubak and Petra. The vegetation in the North is interrupted by other types of forest but it is best represented in Ishtafaina near Ajloun.

Composition:
Three strata can be recognized in well preserved forests:

Stratum 1. Trees or high shrubs:

Quercus coccifera	***Pistacia palaestina***
Pyrus syriaca	***Arbutus andrachne***
Crataegus azarolus	***Phillyrea media***

Stratum 2. Low shrubs and climbers:

Amygdalus communis	***Rhamnus palaestinus***
Asparagus aphyllus	***Rubia olivieri***
Lonicera etrusca	***Calycotome villosa***
Sarcopoterium spinosum	***Cistus villosus***

Stratum 3. Herbaceous:

Dactylis glomerata	***Poa bulbosa***
Anemone coronaria	***Cyclamen persicum***
Echinops spp.	***Linum pubescens***
Lecokia cretica	***Adonis palaestina***
Orchis anatolica	

4.1.3. Deciduous oak forests

The name of this vegetation is derived from the deciduous oak species. Three to four species of ***Quercus*** are used by different workers to designate the vegetation as ***Q. aegilops, Q. boissieri, Q. ithaburensis*** and ***Q. infectoria.*** The taxonomic status of these taxa in Jordan is not clear, although some taxonomist may consider two or even one valid taxon. Whatever the taxonomic treatment is, the species ***Q. ithaburensis*** in this study will be used as the indicative species for the deciduous oak forests in Jordan.

The deciduous oak forests in Jordan occur at a lower altitude than all other forest and mostly grow on red or brown soil of hard limestone parental rock. Most of these types of forest are not well protected. Therefore, they are subject to degradation (**Figs. 4.6, 4.7 & 4.8**). The deciduous oak forests are found at the lower borders of the evergreen oak forests and they mix together for a limited area until they become pure stands of each type alone. If one travels within the Mediterranean region in Jordan he will find scattered old deciduous trees which can be used as

standing witnesses to the fact that degraded forests used to grow in such places.

The composition of deciduous oak forest varies in relation to the amount of humidity and temperature. For example the forests in Um-Qeis and Malka are associated with ***Pistacia palaestina, Ceratonia siliqua, Styrax officinalis, Cercis siliquastrum*** and ***Amygdalus communis;*** while the forest in AL-Alouk is associated with ***Pistacia atlantica, Amygdalus communis, Rhamnus palaestinus*** and ***Retama raetam*** at the margins since the latter forest is at the Irano-Turanian border which receives less rainfall and higher temperature.

In some places like As-Baihi in Salt area, Burma, the slopes at the Southern side of King Talal Dam and in Halawa between Ajloun and Irbid the deciduous oak forest is mixed with remnants of wild olive (***Olea europaea***) trees and shrubs.

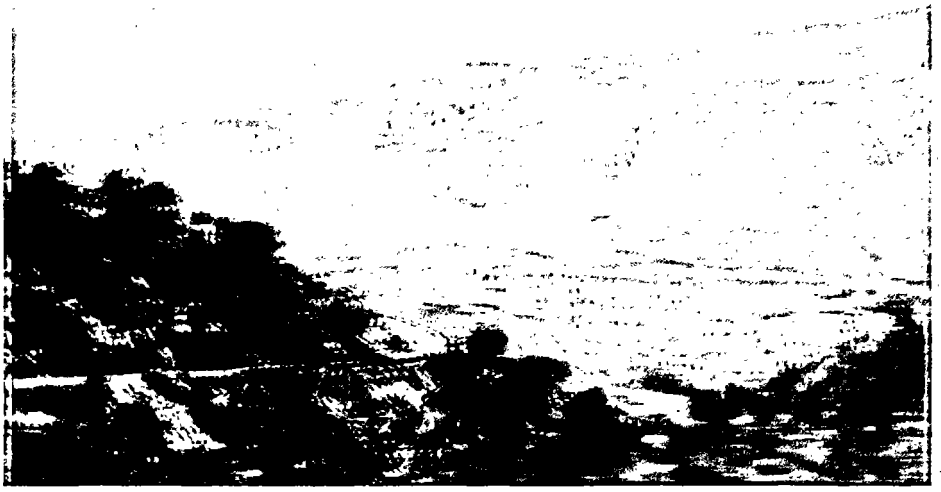
At lower borders of the deciduous oak trees especially at the Western slopes of Jordan mountains descending to the Jordan Valley shrubs of ***Ziziphus nummularia*** will start to mix with oak trees, then they become pure stands of ***Ziziphus nummularia*** until they reach the Jordan Valley. This was clear at the slopes from Halawa to AL-Girim and at the Western slopes of Um-Qeis.

Contrary to that at the Eastern sides of deciduous oak forest, shrubs of Ratam (***Retama raetam***) will start to mix with oak trees until they become pure stands of ***Retama raetam*** when humidity rainfall and altitude become less, and temperature is increased.

Fig. 4.6. Showing deciduous oak forest in AL-Alouk area, Zarka, dominated by ***Quercus ithaburensis*** and ***Pistacia atlantica***.

Fig. 4.7. Showing deciduous oak tree ***Quercus ithaburensis***.

Fig. 4.8. Showing part of the mountain vegetation in Northern Jordan, near Um-Qeis. Notice that North facing slopes are covered by forest vegetation, while South facing slopes are not covered by tree vegetation.



Localities:
Um-Qeis and Yarmuk river; Malka; Dair Abu Said to the borders of Ishtafaina forest in Ajloun; AL-Alouk near Jarash; As-Baihi near Salt; over the hills facing the Zarka river near King Talal Dam; West Mahes on the hills facing Wadi Shuaib and in AL-Bahl ath, West Amman.

Composition:
Three strata, not always clear, can be found with the following leading species:

Stratum 1: Trees:

Quercus ithaburensis	***Styrax officinalis***
Ceratonia siliqua	***Pistacia atlantica***
Olea europaea	

Stratum 2: Shrubs:

Crataegus azarolus	***Olea europaea***
Amygdalus communis	***Calycotome villosa***
Rhamnus palaestinus	***Retama raetam***

Stratum 3: Herbaceous and bushes:

Dactylis glomerata	***Sarcopoterium spinosum***
Urginea maritima	***Euphorbia hierosolymitana***
Carlina hispanica	***Salvia spp.***
Poa bulbosa	***Alcea spp.***
Colchicum spp.	***Tulipa spp.***

4.1.4. Juniper forest

This occurs only in the Southern mountains of Jordan usually at high altitudes, over 1,000m., and so sandy rocks (**Fig. 4.9**).The temperature in the coldest month in the region of this type of forest is usually below zero with snowfall mostly every year. This forest formation extends from Tafila to Ras An-Naqab. The whole forest ecosystem has suffered a great deal of human interaction. Therefore, vast areas were destroyed and almost have no forest vegetation. The extreme sites of such cases occur in Ras An-Naqab, North to At-Taybeh and Petra extending further North to Shaubak. The best stand of this forest is between the wadi at the borders with AL-Mgar'ieh and AL-Mansoura in the South and Bsiarah, near AL-Rashadyiah, Tafila in North. This stand since 1992 has been announced

as a National Park named Dana. The name is taken from the old Dana Village over looking the reserve mountains **(Fig. 4.10)** .

The Juniper forest formation is dominated by the leading species of ***Juniperus phoenica*** associated with ***Cupressus sempervirens*** on the sand stone formation **(Fig. 4.11)**. The Cypressus trees ***Cupressus sempervirens*** are very rare as wild plants and only occur in that particular locality. An old stand of Cypressus tress (Less than 50) are still present in a place called Khunnag AL-Arz, near Ain Lahtha, Tafila **(Figs. 4.12 & 4.13)**. The trees are believed to be of more than one thousand years old. The name Khunnag AL-Arz is based on the trees themselves, since older local people until this moment think that these trees are Cedar (***Cedrus***) trees equivalent to the Arabic name Arz.

In upper altitude over than 1300 m the Juniper forest will be overtopped by a forest formation of evergreen oak forest dominated by ***Quercus coccifera.*** At the line of their meeting mixed forest of ***Quercus*** and ***Juniperus*** will be formed until they are clearly separated as pure stands of each type. This case is very clear in AL-Illami near AL-Qadesieh and near Bir Ad-Dabbaghat and AL-Hisha South of Nijil, Shaubak.

Nevertheless, the second most dominant species occurring within either ***Juniperus*** or ***Quercus*** in ***Pistacia atlantica*** and ***Daphne linearifolia. Pistacia atlantica*** occurs at variable levels in that area ranging from 500-1600 m. Old trees of more than 500 years still present near Bir Ad-Dabbaghat **(Fig 4.14)**. A closely related species has been described as endemic to Shaubak and Petra named ***P. khinjuk.*** A third species is usually associated with ***Juniperus*** and ***Pistacia*** is ***Amygdalus korschinskyi***. Recently few trees of Kharroob ***Ceratonia siliqua*** were discovered within the Dana Reserve on sand stone formation which is an odd finding as previously mentioned.

Localities:

The Juniperus forests almost extend from Rashadyiah near Tafila; Dana; Shaubak; Wadi Musa; At-Taybeh 10 km. S. Wadi Musa; to Dlagha, where few trees are seen.

Fig. 4.9. Showing sand stone formation in Dana Reserve and the scattered tree and shrub vegetation dominated by ***Juniperus phoenica*** and ***Daphne linearifolia***.

Fig. 4.10. Showing top view of Dana Village at the borders of Dana Reserve in Southern Jordan, near Tafila.

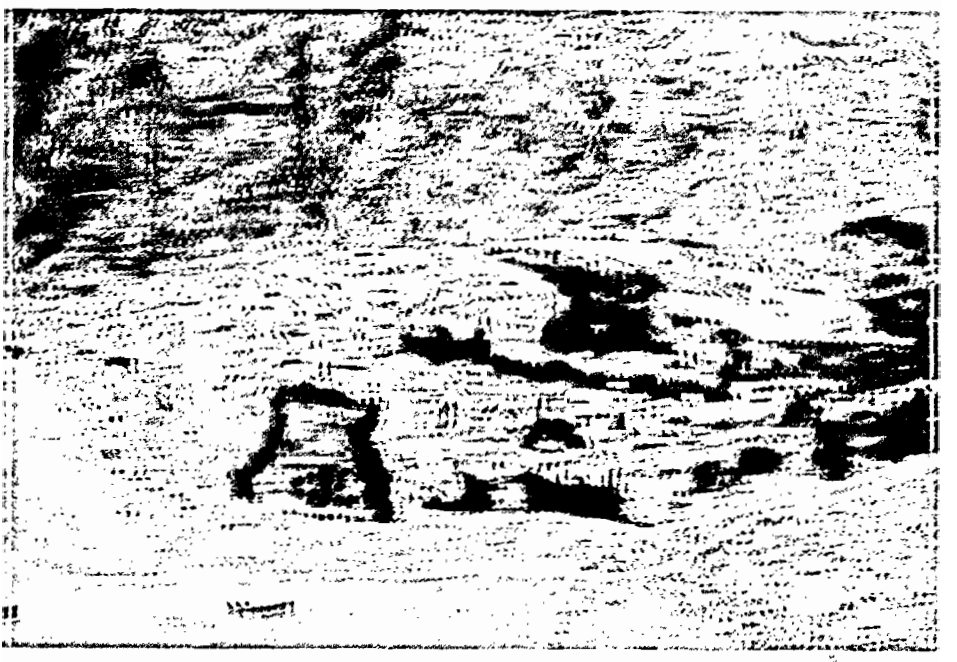


Fig. 4.11. Showing ***Juniperus phoenica*** tree in Southern Jordan near Ain Lahtha, Tafila.

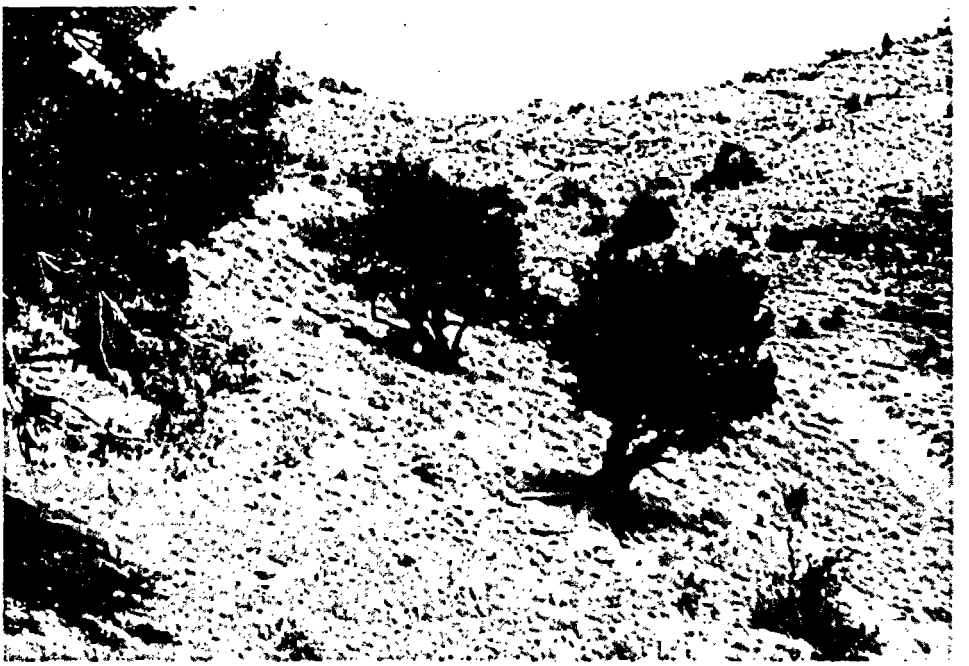
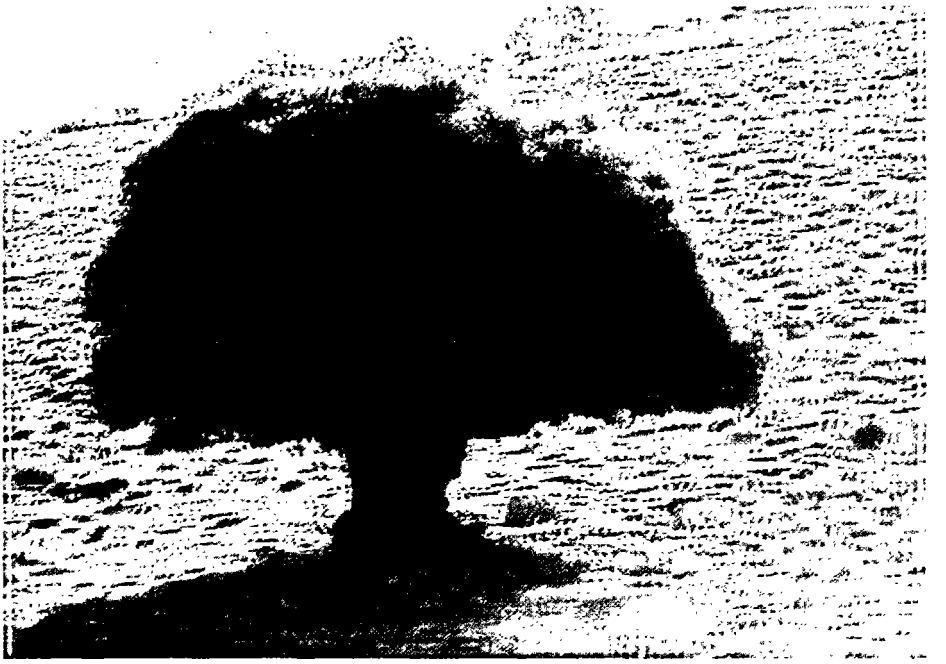


Fig. 4.12. Showing remnants of an old wild stand of ***Cupressus sempervirens*** tree in Khunnag AL-Arz, near Ain Lahtha in Tafila.

Fig. 4.13. Showing a close up photograph for an old ***Cupressus sempervirens*** tree in Khunnag AL-Arz, Ain Lahtha, Tafila. Notice the thickness of the trunk as compared to forest inspector.

Fig. 4.14. Showing an old ***Pistacia atlantica*** tree, near Bir Ad-Dabbaghat, Shaubak as a remnant of destroyed forest.



Composition:
Only two strata can be recognized because of the heavy grazing and the degradation of the vegetation.

Stratum 1: Trees and Shrubs:

Juniperus phoenica	***Daphne linearifolia***
Cupressus sempervirens	***Amygdalus korschinskyi***
Pistacia atlantica	***Colutea istria***
Rhamnus palaestinus	***Crataegus azarolus***
Thymelaea hirsuta	

Stratum 2: Bushes and herbaceous:

Globularia arabica	***Noaea mucronata***
Helianthemum vesicarium	***Achillea santolina***
Sarcopoterium spinosum	***Onobrychis crista-galli***
Osyris alba	***Artemisia herba-alba***
Geranium tuberosum	***Dactylis glomerata***
Zosima absinthifolia	***Scandix iberica***

4.1.5. Mixed forest

Previous workers such as **KASAPLIGIL** (1955) and **TILLAWI** (1989) have considered a special type of forest called mixed forest. I do not find that there is a forest type in Jordan called mixed forest.

It is natural to have two different forest formations at the boundary of each others. Due to that ***Pinus halepensis*** was mixed with ***Quercus coccifera***, ***Q. ithaburensis*** was mixed at with ***Q. coccifera*** at the borders of their distribution. Similar to that is the mixture of ***Quercus coccifera*** with ***Juniperus phoenica*** in Southern Jordan. Based on these facts one cannot consider a special type of forest called mixed, otherwise we have to consider three different new mixed types according to their natural occurrence.

4.1.6. Mediterranean non-forest vegetation

The Mediterranean region which is not covered by forests contains some shrubs and bushes. Such region is often referred to as Garigue and Batha Mediterranean vegetation **(Fig. 4.15)** The leading species of this vegetation are ***Rhamnus palaestinus, Calycotome villosa,***

Sarcopoterium spinosum and ***Cistus spp.*** in the North, and ***Artemisia herba-alba*** will be associated with others in the South.

The Mediterranean non-forest vegetation is treated as degraded forest. Therefore, some scientists believe that if this vegetation is protected, steps toward forest climax will be observed until the final stage is reached.

Localities:
It is found in all the Mediterranean region except the forest lands and the cultivated lands.

Composition:

Rhamnus palaestinus
Echinops spp.
Dactylis glomerata
Teucrium polium
Ononis natrix
Ballota undulata
Eryngium glomeratum
Noaea mucronata
Calycotome villosa
Capparis spinosa
Sarcopoterium spinosum
Hordeum bulbosum
Varthemia iphionoides
Artemisia herba-alba
Poa bulbosa
Thymus capitatus
Asphodelus aestivus
Asparagus aphyllus
and many annuals.

4.1.7. Steppe vegetation

This vegetation is confined to the Irano-Turanian region and may intrude either into the Mediterranean or the Saharo-Arabian region. The composition of the vegetation varies according to the soil and other climatic differences depending on its location with respect to the Mediterranean region. For example the steppe vegetation in the Northern Ghor which links with the Northern mountains is dominated by ***Retama raetam, Ziziphus lotus, Z. nummularia*** and ***Ferula communis*** with almost no ***Artemisia herba-alba***, while the steppe vegetation in the North, East and South Mediterranean borders shows other elements like ***Pistacia atlantica***, ***Anabasis syriaca*** and ***Artemisia herba-alba*** which are not found in the Western steppes **(Figs. 4.16, 4.17, 4.18 & 4.19)**. This might be due to the fact that the Western steppes are more affected by the tropical conditions and vegetation in the Rift Valley, while the Eastern

steppes are more affected by and related to the Sahara conditions and vegetation.

Therefore, variation in the vegetation composition is recognized, a fact that led some workers to distinguish distinct sub-divisions of the major type. However, since it is very difficult to make unambiguous distinction between the different types it would be more advisable not to sub-divide this type of vegetation.

The common features of this type of vegetation are the presence of shrubs and bushes and the absence of tree vegetation.

Localities:
This vegetation forms a strip surrounding the Mediterranean region, except the North.

Retama raetam	*Artemisia herba-alba*
Pistacia atlantica	*Noaea mucronata*
Ziziphus lotus	*Asphodelus aestivus*
Z. nummularia	*Urginea maritima*
Anabasis syriaca	*Ferula communis*
Hammada spp.	*Gypsophila arabica*
Salsola spp.	*Astragalus spinosus*
Tamarix spp.	*Crocus moabiticus*

The vegetation of Wadi AL-Bottom is a special case where *Pistacia atlantica* trees are growing along the Wadi side, especially in the area near Qasr Amra. Although this place is within the Saharan region, its vegetation belongs to the steppe type. Wadi AL-Buttom is an example of intermingling regions, which shows the difficulty in drawing a clear-cut line to delineate the regions. Some of the leading species in this locality:

Pistacia atlantica	*Tamarix spp.*
Retama raetam	*Amygdalus arabica*
Atriplex spp.	

Fig. 4.15. Showing Mediterranean non forest region devoid of any forest formation due to human activity and destruction. The vegetation is dominated by low shrubs of ***Calycotome villosa*** and dense bush cover of ***Sarcopoterium spinosum***.

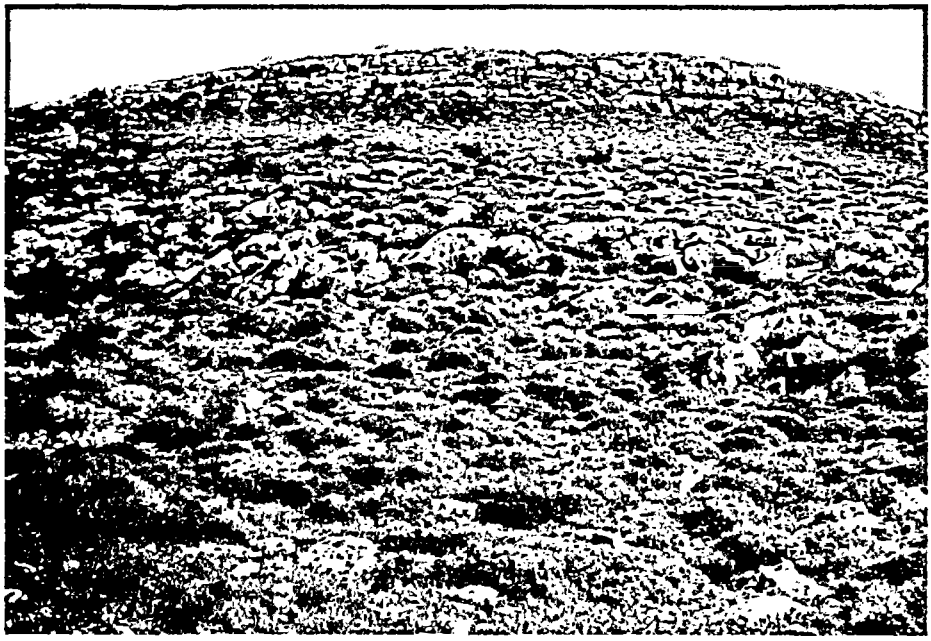


Fig. 4.16. Showing natural Irano-Turanian vegetation dominated by *Noaea mucronata, Asphodelus microcarpus, Artemisia herba-alba, Salvia dominica, Carlina hispanica, Phlomis syriaca, Ballota undulata* and many grasses and herbs (lower), and *Anabasis syriaca* (upper).

Fig. 4.17. Showing part of the Irano-Turanian region (marginal land) which was plowed for cereal production. The result of that is the total destruction of the primary vegetation, the replacement of the primary useful vegetation by a secondary vegetation dominated by a non palatable single species such as this ***Anabasis syriaca,*** and finally soil erosion.

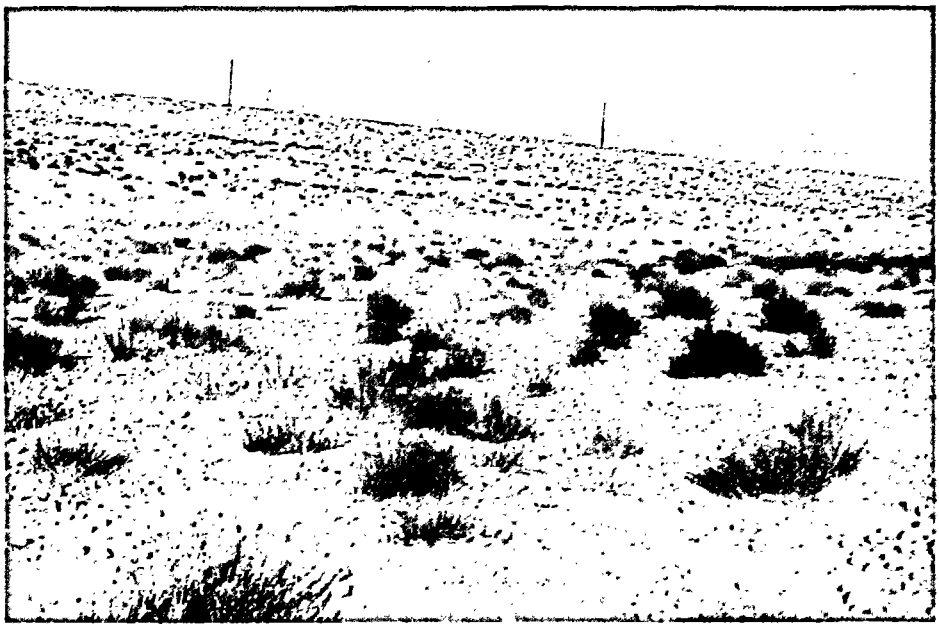


Fig. 4.18. Showing ***Anabasis syriaca*** in flowers and early fruiting, a typical Irano-Turanian element in Jordan.

Fig. 4.19. Showing slopes at the Western side of Dana Reserve, Wadi Finan, dominated by a single species ***Retama raetam***.

4.1.8. Hammada vegetation

Most of the Saharo-Arabian region in Jordan is of hammada type, which comprises about 50 per cent of the total area. Three subdivisions of hammada can be recognized:

1. Run-off hammada
2. Gravel hammada
3. Pebble hammada
4. Sandy hammada

4.1.8.1. Run-off hammada

The vegetation here is mainly confined to the wadis and water-shed places. Usually the vegetation is rich and dense in comparison with the surrounding areas. Run-off places vary in width from few meters to hundreds of meters (**Fig. 4.20**). For example Wadi Bayer is about one km. or more in width in some places, while Wadi Rajil (**Fig. 4.21**) and Wadi AL-Hazeem are one to two hundred meters at most. The vegetation varies from place to another, for example some wadis along the road from Ma'an to Mudawwarah at Saudi Arabia borders, the wadi has ***Acacia tortilis, A. raddiana, Tamarix spp., Artemisia judaica*** and ***A. monosperma***. Wadi Bayer has the shrub formation dominated by ***Lycium sp.*** and ***Retama raetam***. The vegetation of Wadi AL-Hazeem (**Fig. 4.22**), the tree species is ***Phoenix dactylifera***, while the shrub species is ***Nitraria retusa.*** Contrary to the previous cases the vegetation of Wadi AL-Bottom, near Qasr Amra (**Figs. 4.23, 4.24 & 4.25**) is dominated by ***Pistacia atlantica*** (a Mediterranean element penetrated into the desert due to the presence of water), ***Retama raetam*** and ***Amygdalus arabica***. In general the leading species are:

Retama raetam	***Tamarix spp.***
Atriplex halimus	***Peganum harmala***
Lycium europaeum	***Astragalus spp.***
Artemisia herba-alba	***Anabasis articulata***
Achillea fragrantissima	***Atractylis mutica***
Phlomis brachyodon	***Gynandriris sisyrinchium***

Fig. 4.20. Showing run-off wadi with few vegetation species. The most important are ***Anabasis articulata, Halogeton alopecuroides, Halothamnus acutifolius, Colchicum tunicatum*** and ***Ducrosia flabellifolia.***

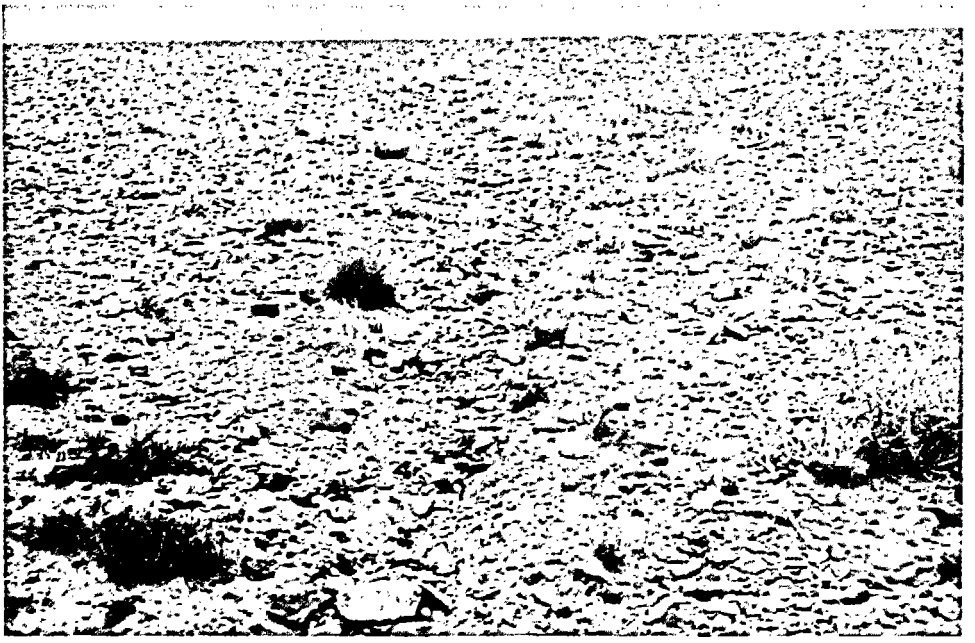


Fig. 4.21. Showing Wadi bed in the Eastern Desert covered by rather dense vegetation. The most important elements are: ***Artemisia herba-alba, Astragalus spinosus*** and ***Achillea fragrantissima***.

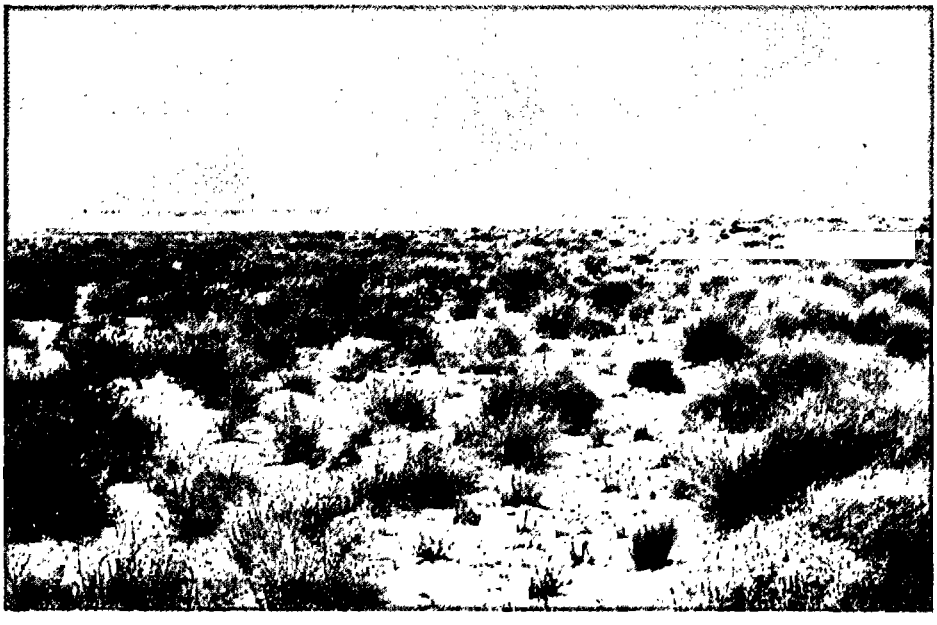


Fig. 4.22. Showing thick vegetation in a Wadi bed in AL-Hazeem area, Eastern Desert. Notice wild palm ***Phoenix dactylifera*** and ***Nitraria retusa***.

Fig. 4.23. Showing Wadi AL-Bottom, near Qasr Amra, in the Eastern Desert (Badia).

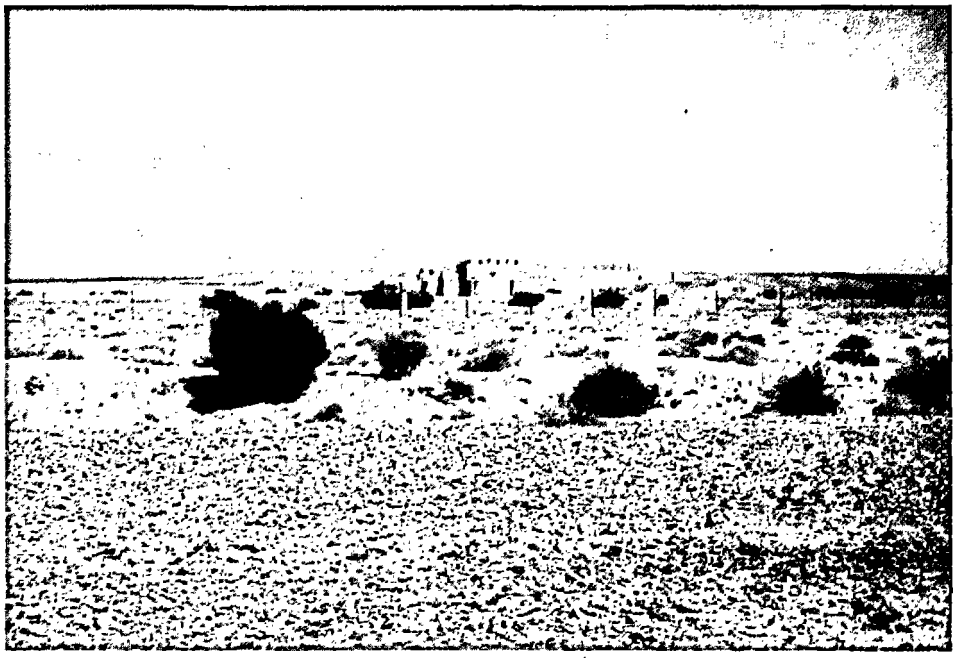
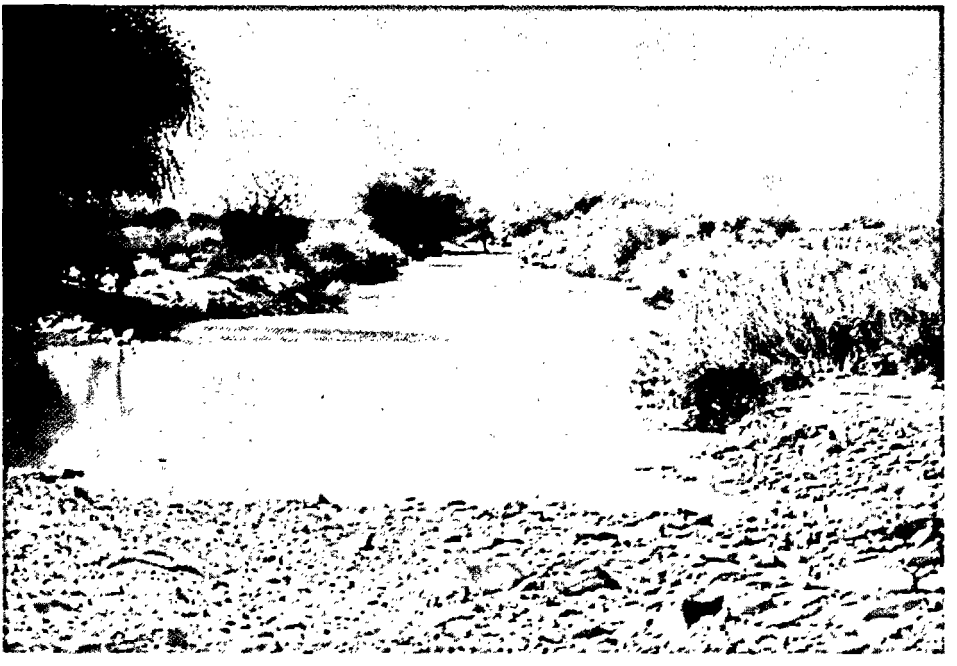


Fig. 4.24. Showing a tree of ***Pistacia atlantica***, and shrubs of ***Retama raetam*** in Wadi AL-Bottom, Eastern Desert.

Fig. 4.25. Showing Wadi AL-Bottom with water floods during a rainy season. This is the major reason for the survival of the Atlantic Pistachio ***Pistacia atlantica*** in the heart of the Eastern Desert.



4.1.8.2. Gravel hammada

Gravel hammada is the largest, flattest part of Jordan, restricted to middle of the Eastern Desert. It is made of mostly clayey loam covered by gravels especially near Qasr AL-Harranah (**Figs. 4.26 & 4.27**). The vegetation is dominated by some low shrubs such as ***Seidlitzia rosmarinus*** in association with some annual herbs and succulent plants. The following are some of the leading species:

Seidlitzia rosmarinus	***Mesembryanthemum nodiflorum***
Spergularia diandra	***Filago desertorum***
Herniaria hirsuta	***Gymnarrhena micrantha***
Aaronsohnia factorovskyi	***Stipa capensis***
Anthemis deserti	***Bromus spp.***
Asteriscus pygmaeus	***Trigonella stellata***

4.1.8.3. Pebble hammada or Harrah

The land is covered by black pebbles which make driving almost impossible, and walking very hard. Unless cleaning tracks by removal of stones by compressing no chance one can travel by a vehicles on this land (**Fig. 4.28**).

The black stones are sometime covered by lichens especially at the North facing sides. The lichen cover turns the black colour of the pebbles into white-grey growth (**Fig. 4.29**). The pebble hammada covers a vast area stretching from Mafraq to almost Ruwaished (H4) up to the borders with Syria in the North. The Vegetation is dominated by some chenopod plants especially ***Salsola vermiculata*** and ***Halogeton alopecuroides***. If one visits this area in summer time he will think that it has no vegetation cover, but if that visit was made in a rainy season, he will be astonished by the richness and diversity of vegetation (**Fig. 4.30**). The leading species are:

Salsola vermiculata	***Halogeton alopecuroides***
Anabasis articulata	***Diplotaxis harra***
Linum album	***Achillea fragrantissima***
Thymus bovei	***Euphorbia retusa***
Paracaryum rugulosum	***Alcea chrysantha***
Hammada eigii	***Atriplex leucoclada***
Zilla spinosa	***Lepidium aucheri***

Fig. 4.26. Showing part of the Eastern Desert, covered by gravels Hammada soil type, near Qasr AL-Harranah (AL-Kharranah).

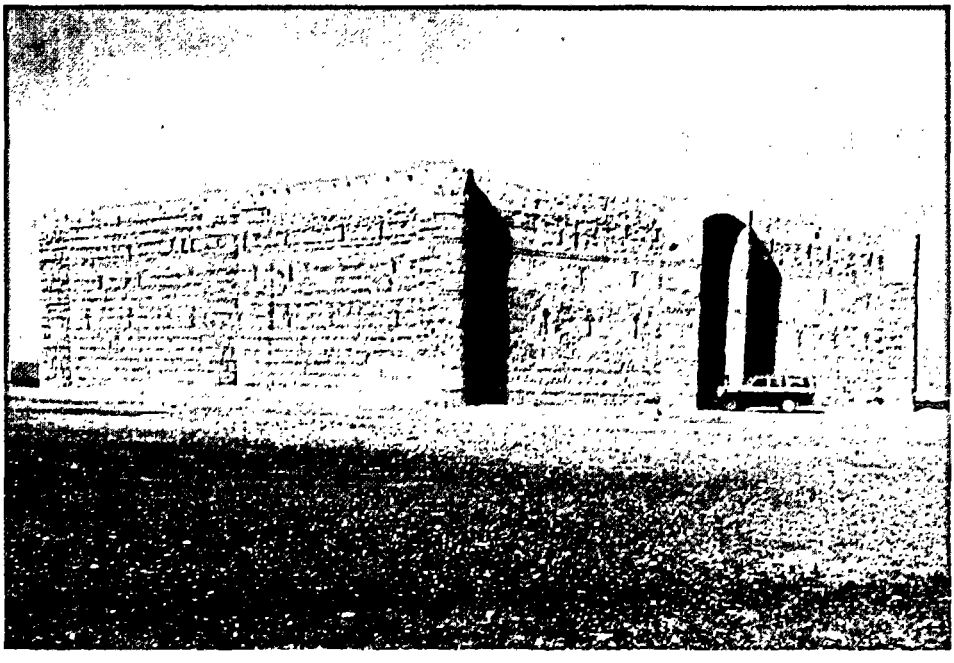


Fig. 4.27. Showing part of the Eastern Desert (Badia), covered by gravels. Notice the flattened nature of the Badia, and the scarce vegetation.

Fig. 4.28. Showing part of the Eastern Desert, North-East of Jordan covered by basaltic pebbles hammada soil type called AL-Harrah.

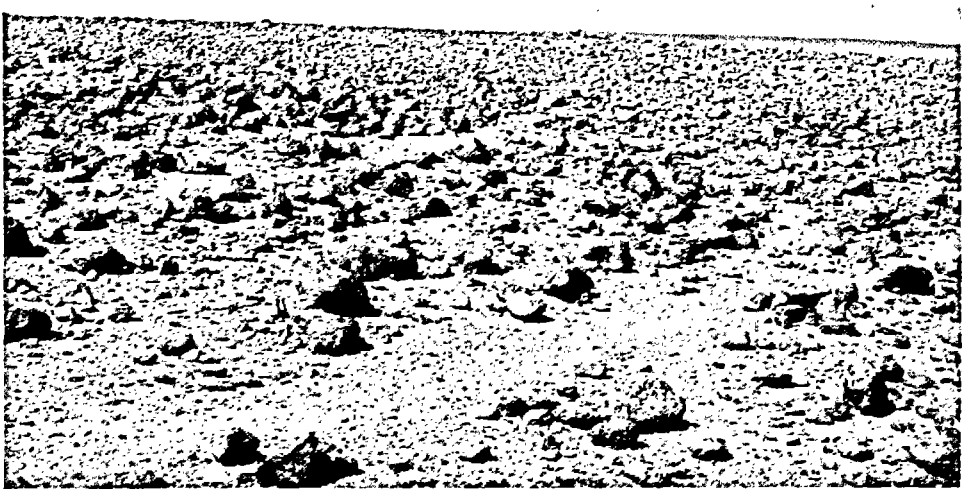


Fig. 4.29. Showing basaltic stone (pebbles) in the Eastern Desert covered by lichens especially at the North facing side. Therefore, the black colour of the stones is becoming white due to the lichen growth.

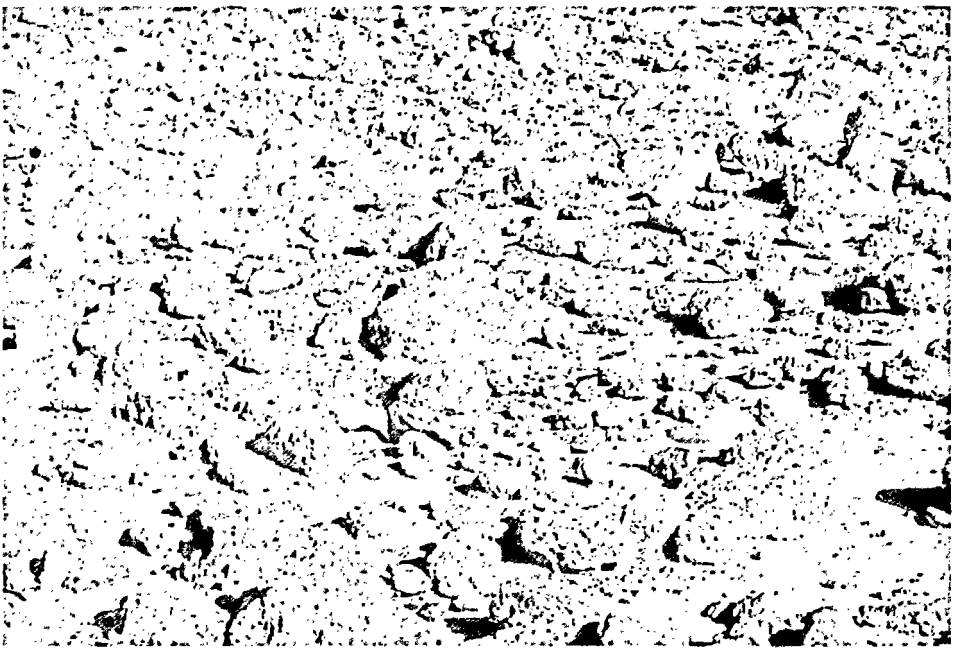
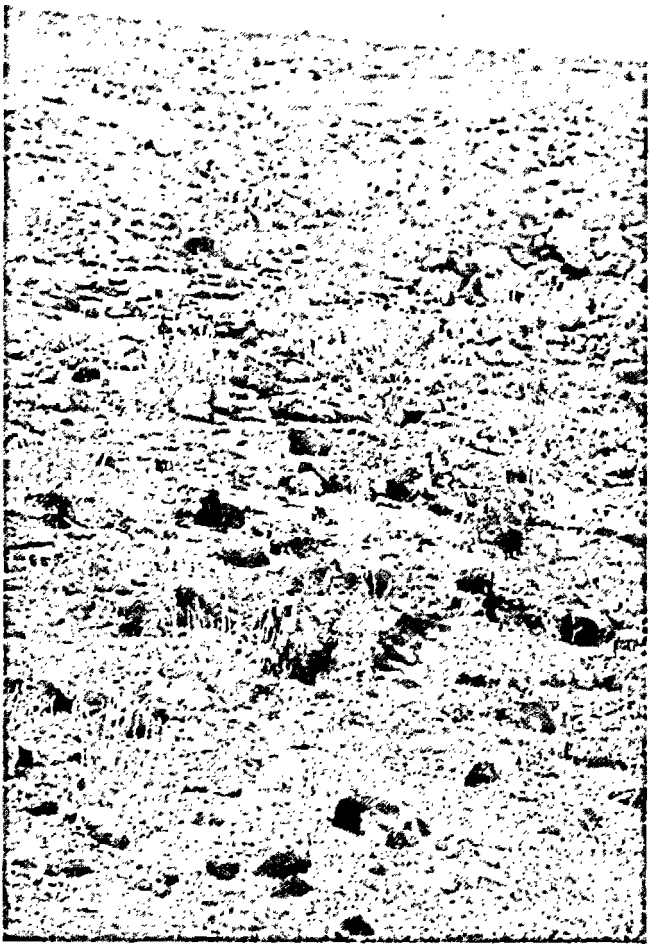


Fig. 4.30. Showing Eastern Desert covered by pebbles during a rich vegetation season. Notice ***Glaucium arabicum, Linum album, Halogeton alopecuroides, Diplotaxis harra.*** Notice also that the black stones are covered by white lichen growth.



4.1.8.4. Sandy hammada

Most common along the borders with Iraq and Saudi Arabia along the road to AL-Wisad police station (**Fig. 4.31**), and partially in Ash-Shumari reserve. The land is a mixture of either type of hammada, gravel or pebbles, with sandy soil coming from Saudi Arabia. In some cases the sandy soil will be dominant and sand dunes formations may occur. The leading species are:

Seidlitzia rosmarinus
Atriplex spp.
Artemisia herba-alba
Anabasis articulata
Achillea fragrantissima
Halocnemum strobilaceum
Capparis leucophylla
Ephedra transitoria
Deverra triradiata
Calligonum tetrapterum
Zilla spinosa

4.1.9. Saline (Halophytic) vegetation

This occurs in the desert (Saharo-Arabian) region around Azraq Oasis, in the Rift Valley around the Dead Sea, in Wadi Araba, and around the shoulders of the River Jordan on what is known locally as Katarat. The leading species vary, depending on their ability to tolerate the degree of salinity. For example *Nitraria retusa* (**Fig. 4.32**) is a saline tolerant species but it does not grow if the salinity exceeds certain limits and will be replaced by other species such as *Arthrocnemum fruticosum, Suaeda spp. Juncus sp.* (**Fig. 4.33**) and *Tamarix spp.* Therefore, if we take a line transact from the Dead Sea shore to the hilly areas, the arrangement of species starting from the water will be *Suaeda spp., Arthrocnemum spp., Juncus spp., Tamarix spp., Nitraria, Ziziphus lotus, Anabasis setifera, Rhus tripartita, Zygophyllum dumosum* (**Fig. 4.34**), *Anabasis articulata*. Some of the leading species are the followings:

Arthrocnemum spp.
Suaeda spp.
Juncus littoralis
Limonium meyeri
Tamarix spp.
Lycium spp.
Nitraria retusa
Sonchus maritimus
Frankenia pulverulenta
Aeluropus littoralis
Desmostachya bipinnata
Prosopis farcta
Alhagi maurorum
Beta vulgaris
Inula crithmoides
Rhus tripartita

Fig. 4.31. Showing AL-Wisad Police Post Station at the Eastern Desert borders with Saudi Arabia. Notice the deposits of sand on the basaltic stones due to the swiveling and transportation of sand from the East coming from Saudi Arabia.

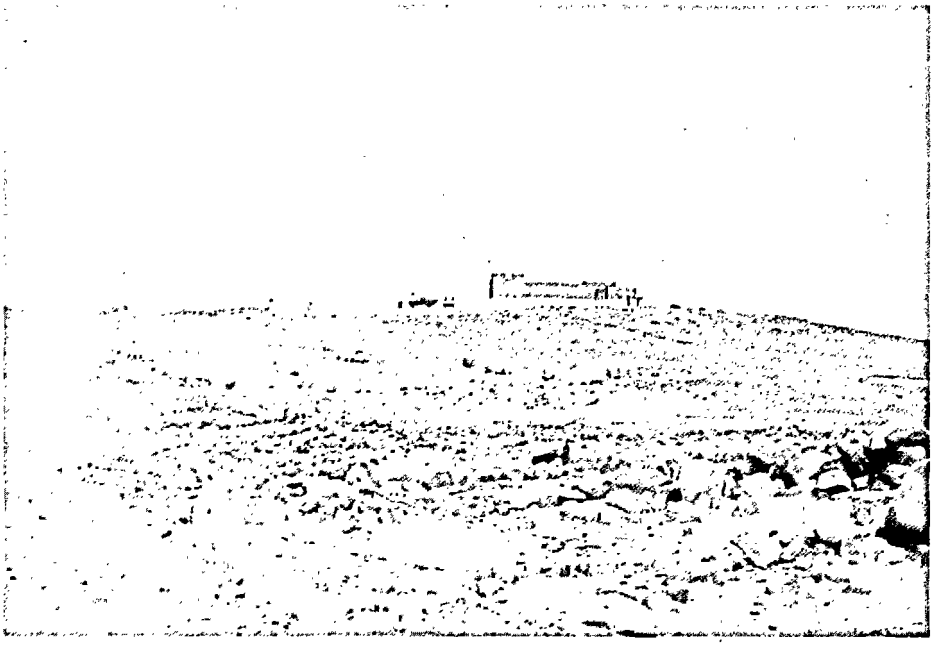


Fig. 4.32. Showing saline soil and saline vegetation, dominated by *Nitraria retusa* (Ghargad), at the Northern end of the Dead Sea, near Suwaimah.

Fig. 4.33. Showing saline vegetation at the Southern end of the Dead Sea. Vast areas have been used as a site of the Arab Potash Company or used for cultivation after being desalinated. The dominant plants are ***Juncus acutus, Suaeda spp.*** and ***Arthrocnemum fruticosum.***

Fig. 4.34. Showing hills at the Eastern side of the Dead Sea. Vegetation is degraded due to heavy grazing. The dominant elements on such slopes usually are: ***Anabasis articulata, Zygophyllum dumosum*** and ***Gymnocarpos decandrum.***

4.1.10. Tropical vegetation

It occurs in the Sudanian region which extends from Dair'Alla in the North down to Aqaba Gulf in the South but it is concentrated more in the regions close to the Dead Sea, lower Jordan Valley **(Fig. 4.35)**, as in Southern Ghor, Ghor Safi and Ghor Faifa. The vegetation is confined to the alluvial soils of the Rift Valley most of which have been destroyed and used for vegetable agriculture. There is no protected part, but if some places like Ghor Faifa are protected it will definitely reach the climax. The leading species are **(Fig. 4.36)**:

Ziziphus spina-christi	*Ochradenus baccatus*
Calotropis procera	*Acacia raddiana*
Balanites aegyptiaca	*Cocculus pendulus*
Maerua crassifolia	*Aerva spp.*
Salvadora persica	*Forsskaolea tenacissima*
Moringa aptera	*Capparis decidua*

4.1.11. Sand dune vegetation

Such vegetation is only found in the Sudanian region especially in Wadi Araba and Wadi Rum **(Figs. 4.37 & 4.38)**. The vegetation is made up of shrubs or bushes, mainly of sand dune fixatives. In some places the vegetation has reached its climax especially in the area near to Gharandal along the road to Aqaba where the plants reach a height of three meters.

The leading species are:

Haloxylon persicum	*Plantago ovata*
Retama raetam	*Plantago cylindrica*
Calligonum comosum	*Stipagrostis spp.*
Panicum turgidum	*Savignya parviflora*
Hammada scopira	*Arnebia spp.*
Dipcadi erythraeum	*Eremobium aegyptiacum*
Pancratium sickenbergeri	*Cakile maritima*
Hyoscyamus pusillus	*Schismus barbatus*
Neurada procumbens	*Silene villosa*

Fig. 4.35. Showing remnant of tropical forest in Jordan valley, due to heavy cultivation. Notice small trees of ***Ziziphus lotus, Z. spina-christi, Balanites aegyptiaca*** and cultivated Palm tree ***Phoenix dactylifera***.

Fig. 4.36. Showing *Moringa peregrina* a typical tropical element found near the hot springs at the Eastern side of the Dead Sea. This plant is a rare plant in Jordan, it is found in Wadi Finan and near the Dead Sea. A single half destroyed plant was found near AL-Kafrain Dam, near AL-Rawda, Lower Jordan Valley.

Fig. 4.37. Showing sand dune vegetation in Wadi Araba, dominated by *Haloxylon persicum*.

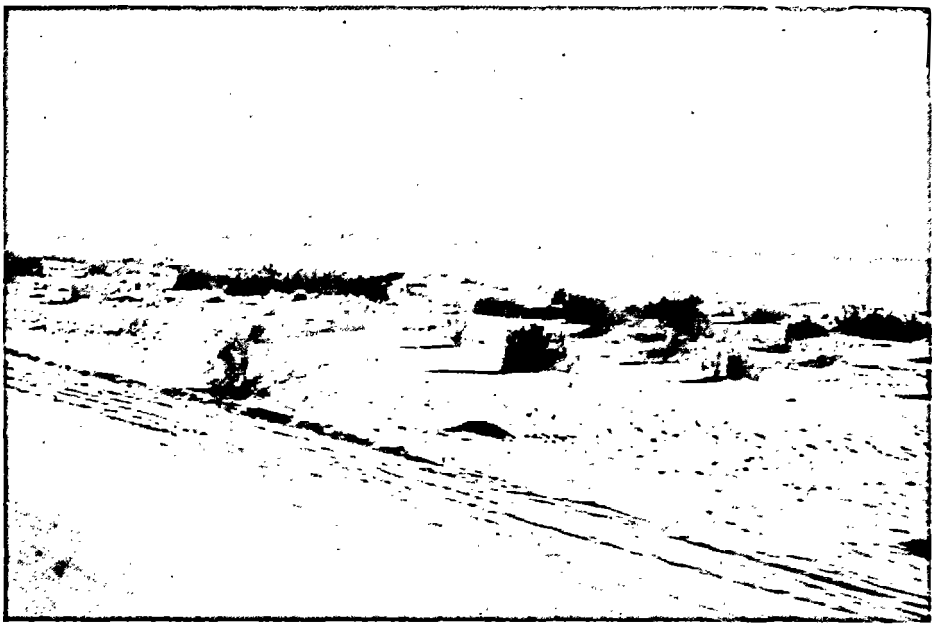
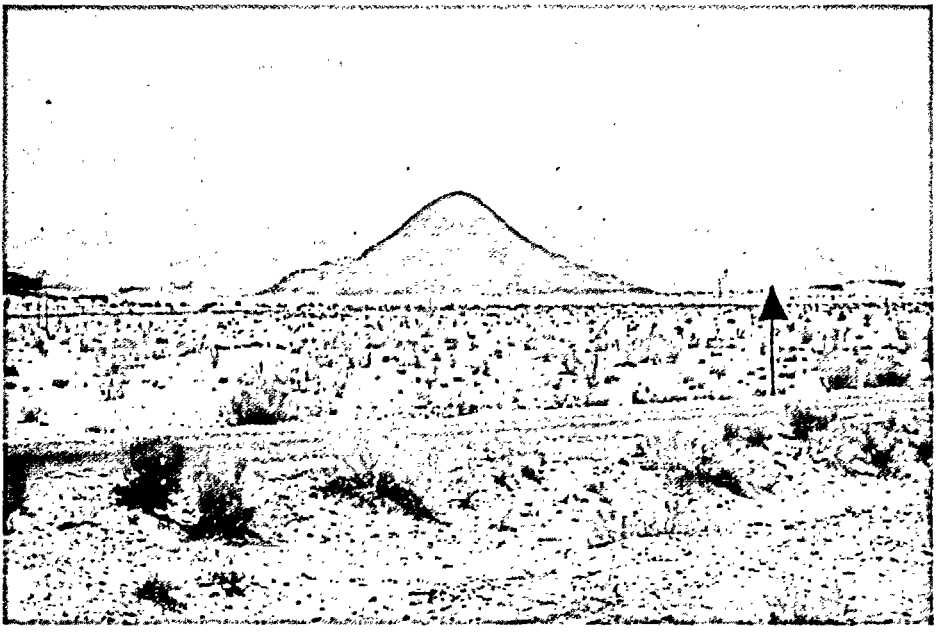


Fig. 4.38. Showing part of Wadi Rum and sand dune vegetation dominated by ***Haloxylon persicum***.



4.1.12. Acacia and Sudanian rocky vegetation

This vegetation is confined to the granite mountain bases and to the rocky part of Wadi Araba, Aqaba, Wadi AL-Yutm, and Wadi Rum in the Sudanian region **(Figs. 4.39 & 4.40)**. *Acacia* trees are scattered through Wadi Araba but they get more dense toward the hard rocks of the mountain bases until they form a pure stand of *Acacia* woodland especially 20-40 km. before Aqaba. Within the same habitat and on the hilly ground covered with hammada a special type of plant grows, with the following leading species:

Acacia raddiana
Acacia tortilis
Anabasis articulata
Hammada scopira
Cassia italica
Zygophyllum dumosum
Caralluma spp.
Traganum nudatum
Fagonia spp.
Reaumuria hirtella
Gymnocarpos decandrum
Helianthemum lippii
Asteriscus graveolens
Sclerocephalus arabicus
Anastatica hierechuntica

4.1.13. Water (Hydrophytic) vegetation

This occurs around the streams and river banks and around the water pools in Azraq. The vegetation does not occur much in Jordan but still it is clear around Jordan river; Yarmuk river; Zarka river; Wadi Shuaib; Wadi Mujeb; Wadi AL-Hasa and in Azraq Oasis **(Figs. 4.41, 4.42, 4.43 & 4.44)** . The leading species are:

Salix spp.
Phragmites australis
Vitex angus-castus
Cyperus longus
Tamarix spp.
Typha domingensis
Nerium oleander

4.1.14. Mud flats (Qaa' or Bajada)

These are places in the desert where water accumulates and soil is made of very fine particles, mainly of clay and silt. After the water evaporates the soil becomes solid and very hard, which does not help any plant to germinate and survive. Examples of this are Qaa' AL-Jafr and Qaa' AL-Disi, Qaa' AL-Azraq, Qaa' Shbaikah, Qaa' Ad-Dahik **(Fig. 4.45)** and

some others distributed in the Eastern desert of Jordan. Usually on the Qaa' there will be no vegetation, but in the peripheries some plant will grow, examples of these species are:

Capparis ovata	*Frankenia hirsuta*
Nitraria retusa	*Suaeda spp.*
Tamarix spp.	*Aeluropus littoralis*

Fig. 4.39. Showing Eastern part of Wadi Rum near Sahl As-Suwwan. Notice *Acacia raddiana*.

Fig. 4.40. Showing Granite Mountains and rocky *Acacia* tropical vegetation at the Southern end of Wadi Araba, 30-40 km North of Aqaba.

Fig. 4.41. Showing grasses near the fresh water hot spring at the slopes of the Dead Sea area. A rare Orchid ***Epipactis veratrifolia*** is growing in this type of habitat. Most of such habitats have been destroyed for vegetable production.

Fig. 4.42. Showing mouth of Wadi Mujeb at the joining point with the Dead Sea.

Fig. 4.43. Showing AL-Ghadeer in Ma'an, a previous water spring forming a localized Oasis in old days. This part now is in the heart of Ma'an city. Notice ***Typha domingensis*** and ***Phoenix dactylifera.*** The fern ***Adiantum capillus-veneris*** was collected from that desert locality.

Fig. 4.44. Showing part of Azraq village and Azraq Oasis. Notice dry land due to the over pumping of water and thus the disappearance of wet land, and destruction of natural habitats due to human over exploitation of this natural resources.

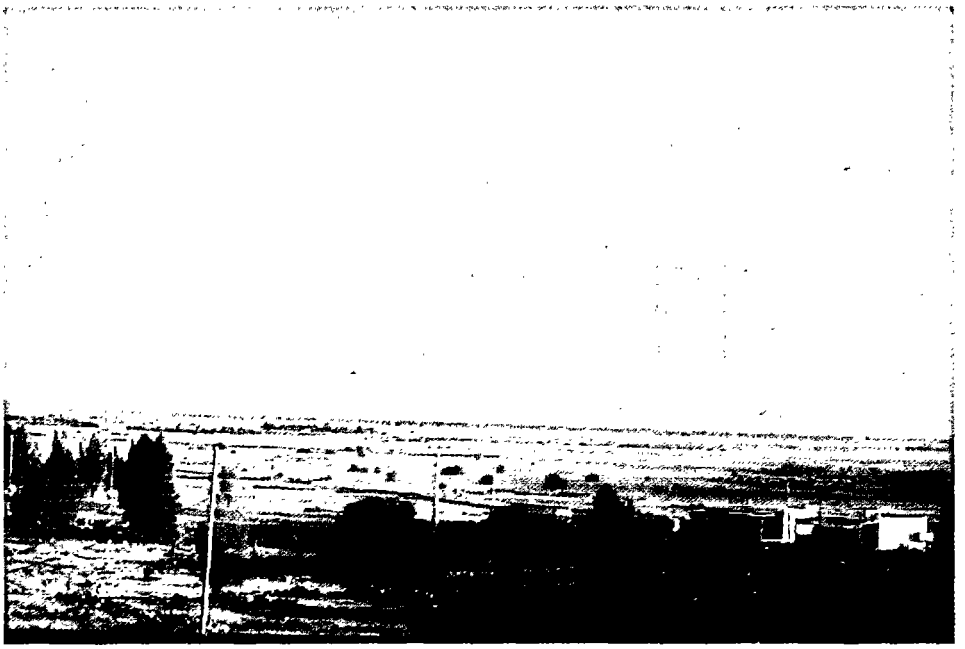
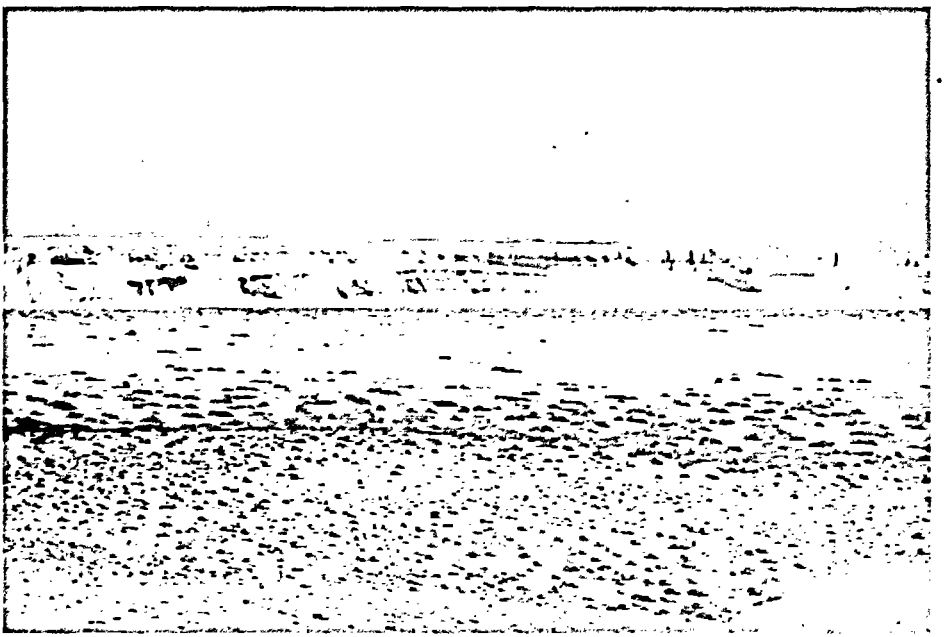


Fig. 4.45. Showing Qaa' (Bajada) Ad-Dahik, Eastern Desert, East of Azraq. Notice some halophytic plants at the margin and the chalky rocks at the back ground.



5. VEGETATION OF SPECIAL AREAS IN JORDAN

5.1. Karak Province

5.2. Wadi Araba

5.3. Wadi Shuaib

5.4. Dana Reserve

5.5. Azraq Basin

5.6. Shaumari Reserve

5.1. Karak Province

5.1.1. Physical aspects of the region

5.1.1.1. Location

Karak governorate covers a wide geographical area extending from the Eastern Desert in the East to the Dead Sea and part of Wadi Araba, especially Ghor Safi and Ghor Faifa in the West. And from Wadi Mujeb in the North to Wadi AL-Hasa in the South.

5.1.1.2. Altitude

The whole area falls within a variable altitude ranging from 600m in the East to about 1000 m or more in the middle and down to -395 m at the Dead Sea in the West. Similarly the altitude varies from North with a sudden depression at Wadi Mujeb, then passing through a high mountain ranges such as Shihan, until it descends into another depression in the South at Wadi AL-Hasa.

5.1.1.3. Temperature

Temperature in the whole area in terms of minimal and maximal temperatures is very variable. In the Dead Sea area and Wadi Araba temperature is warm in winter 10-20°C and very hot in summer 35-45°C. In the mountain areas the minimal temperature ranges from -5 to 15°C in winter and 20-30°C in summer. While in the Eastern Desert the minimal temperature ranges from -5 to 20°C in winter and 20 to 40°C in summer.

5.1.1.4. Rainfall

Rainfall is also distinctly variable, it ranges from only 50 mm in the Dead Sea and Ghor Safi to about 400 mm in the mountain and decreases again to the Eastern Desert where it falls down to 100 mm near AL-Qatrana. It is clear that the best rainfall occurs in the mountain ranges especially in Shihan mountain, AL-Qasr, AL-Rabbah, Karak, Mu'ta and AL-Mazar. Occasionally the mountain ranges receive snowfalls in the winter times. Often more than one snowfall may occur in one year, which can be very heavy to block the main roads for few days.

5.1.1.5. Soil and land use

Soil type accordingly is very much affected with the previous physical aspects of the region, affecting in turn the soil type and soil genesis in the area.

In general the best soil formations occur in the mountain ranges where the best rainfall and medium temperatures occur. Terra Rossa (Red Soil) and dark brown to blackish soils are dominant types in the mountain regions.

This soil is fertile and forming the majority of the arable land in the region. This land usually is the major part of cereal and crop cultivation based on natural rainfall irrigation. Therefore, most of the crops are classified as winter crops since seeding starts in November and harvesting starts in May, and these are Cereals, Lentil, Chick Pea and Vetch, or summer crops such as summer vegetables; Watermelon, Squash, Calabash, Tomato; or fruits of Grapes, Apples and Olives. In the Eastern part of the province the soil will be either:

A. Heavy deposits of loess soil
B. Poor shallow calcareous soil
C. Hammada soil of both types gravel and pebbles

All of these soil types are used under natural condition as range lands. Recently, loess soil lands have been used for vegetable production based on irrigation. Lots of wells have been drilled in the aquifers and water have been used for crop production especially Potato, Tomato, Cabbage, Cauliflower and Watermelon.

In the Western part of the province, the following types can be recognized:

A. Poor shallow calcareous soil
B. Alluvial soil
C. Lisan marls
D. Saline soil
E. Sandy soil

Most of these types are used as natural range land for sheep or goat grazing. Some of the alluvial soils, saline soils and sandy soils have been

used for cultivation under irrigation. Some saline soils have been washed and supplied by drainage systems of ditches to be used successfully.

Crops produced in this area are very important economically speaking since they are produced off season especially in the critical cold season of the year. Therefore, a great interest in this area is increasing with time and more area has been newly invested in agriculture. Examples of these crops are Tomato, Pepper, Egg plant, Squash, Guava, Lemon, Banana.

5.1.2. Phytogeographical regions

According to the physical properties of this area and according to previous studies concerned with vegetation of Jordan (**AL-EISAWI**, 1985), the study area includes the total four biogeographical regions recognized in the country. These regions are in sequence from East to West:

A. Saharo-Arabian.
B. Irano-Turanian.
C. Mediterranean.
D. Sudanian (or Tropical).

The Irano-Turanian is surrounding the Mediterranean region from both sides East and West. Therefore, these four regions in this province are forming a cross section through the vegetation regions of Jordan since they are parallel from North to South.

5.1.2.1. Saharo-Arabian region

This area comprises the Eastern part of the province within it the desert Amman - Aqaba high way passes as well as the old Hijaz railway line which is used now only for phosphate transport to Aqaba. The rainfall ranges from 50-100 mm per year. The soil is of the hammada type dominated by the gravel type and rarely pebbles. This region is well known in Jordan to be flattened, but in this province has some hilly places.

The land is usually used as natural range land for grazing without any planning for better use. Exceptional from that is a small agricultural

station in Qatrana where limited irrigated cultivation is present. The crops produced are Alfalfa, Barley and some vegetables.

Due to the bad use of land overgrazing is harmly affecting this territory, thus soil is eroded and natural vegetation is limited. Some human activities have increased the destruction of natural vegetation through plowing the land especially in wadi beds and runoff area for Barely cultivation. In some places thousands of hectares have been destroyed through activities which have caused the destruction of the previous primary vegetation. Often the aim of these human activities is just the ownership of government land. This behaviour unfortunately often gives local tribes and persons a legitimate right to own the land being used by them for many years.

The dominant natural vegetation in this region is mainly chenopod elements such as: ***Anabasis articulata, A. syriaca, Hammada eigii, Halothamnus acutifolius, Salsola inermis*** and other non-chenopods as: ***Gymnarrhena micrantha, Herniaria hirsuta, Poa bulbosa, Crocus cancellatus subsp. haussknechtii.***

In wadi beds and run-off places other vegetation elements occur such as: ***Artemisia herba-alba, Astragalus spinosus, Achillea fragrantissima, Trigonella stellata, Colchicum tunicatum.***

5.1.2.2. Irano-Turanian region

This region as mentioned earlier surrounds the Mediterranean region from both sides east and west. The rainfall ranges from 100-250 mm per year. Soil type is either calcareous or loess.

Most of this area is used as natural range land for grazing. A natural reserve has been initiated by the name of AL-Lajoun since 1981 with a total area of 11,000 Dunom. This range reserve is not absolutely protected, nevertheless it shows the richness and diversity of vegetation. It is great to have such reserve in this area which acts as a natural in-situ seed and gene bank for the biodiversity of the region.

Other parts of this region close to the Mediterranean territory which have high deposits of loess soil have been recently used for the cultivation of irrigated vegetables.

The dominant vegetation elements in this territory are: ***Artemisia herba-alba, Salsola vermiculata, Atriplex halimus, A. leucoclada, Noaea mucronata, Urginea maritima, Crocus cancellatus subsp. haussknechtii, Poa bulbosa, Diplotaxis harra, Erucaria pinnata, Sternbergia clusiana, Lactuca orientalis, Anabasis syriaca.***

5.1.2.3. Mediterranean region

This is the most fertile region in the country since it receives the highest amount of rainfall in the province as well as the highest altitude and the lowest grades of temperature.

The Mediterranean region in Jordan is usually holding the best type of vegetation. This vegetation is reaching its climax in forming forest stands of either evergreen oak forest, deciduous oak forests, Aleppo pine forest or juniper forests. Unlike all other part of the country with Mediterranean regions, this particular region is totally devoid of any natural forest formation. However, since its position is in the middle of this whole Mediterranean territory in the country, and since the Northern parts and the Southern parts are covered by natural forest formations of various types, then the only explanation is that it was covered by some sort of forest formation but has been destroyed through heavy human activities.

It is very appropriate to say that the most accepted reason for not having forest in this region is human impact (**AL-EISAWI**, 1994). The justification of that, is the present physical characteristics of this region are similar to other parts covered by forest. Altitude, rainfall, soil types and temperatures are as good as other places with forest formation.

In fact serious search has revealed remnants of forest formation as present by some forest indicators such as: ***Amygdalus communis, Rhamnus palaestinus*** and ***Crataegus azarolus.***

This vast Mediterranean region is used heavily for crop production as mentioned previously. It is believed that the destruction of the forest formation was made through the past two to three millennia since this area and other areas in the South have always been heavily inhabited by previous civilization such as Islamic, Roman and Nabatean (**ORAN**, 1994).

The vegetation types present in this area have some typical Mediterranean element such as: ***Sarcopoterium spinosum, Dactylis glomerata, Lathyrus cicera, Ononis natrix, Psoralea bituminosa, Ophrys sphegodes, Sanguisorba minor, Amygdalus communis.***

5.1.2.4. Tropical or Sudanian region

This area extends around the Southern end of the Dead Sea and the flattened areas in the Rift Valley. Such area is characterized by low altitude, high temperature and very little amount of rainfall.

The richness of water reserve as accumulated from the seepage of water falling at the high mountains at both sides East and West of the Rift Valley, has caused the formation of special type of vegetation recognized as Sudanian Tropical vegetation. The trees can reach a height up to 7-10 m

In fact some places until now still have thick formation of such forest vegetation especially near Ghor Faifa and Ghor Safi dominated by: ***Ziziphus spina-christi, Z. lotus, Maerua crassifolia, Salvadora persica, Balanites aegyptiaca, Calotropis procera, Acacia tortilis, A. raddiana, Ochradenus baccatus.*** These are typical tropical elements which have penetrated this specific area of the Rift Valley, Dead Sea, Aqaba and Wadi Rum.

Other places with saline soil have thick vegetation formation of halophytes such as: ***Suaeda aegyptiaca, Arthrocnemum macrostachyum, Juncus acutus, J. maritimus, Nitraria retusa, Mesembryanthemum nodiflorum*** and so on. One of the dense saline vegetation location was exactly in the same place of the present Potash Plant in Ghor Safi at the Southern end of the Dead Sea. Some others in the same area have been cleared and leached for crop production.

5.2. Wadi Araba

Wadi Araba is about 180 km long and lies between the longitudes 35°W.-35° 30′E. and the latitudes 31° 20′N.-29° 20′S.

Wadi Araba is a part of the Rift Valley in Jordan, hence the elevations vary from about 200m or more bellow the sea level up to 100m or more above the sea level. The temperature varies from 0°C at night in winter up to over 40°C during summer days. But the mean maximum temperature during the summer is 39°C while the mean minimum temperature in winter is 11°C. The annual rainfall ranges from 0-50 mm or rarely more.

According to **ZOHARY** (1962), three major soil types are present in Wadi Araba and these are: a) saline soils, b) sandy soils with some places of sand dunes, c) hammada especially in the elevated areas. Usually the soils in the Eastern side of the wadi are mixed with granite gravels. The ratio of the gravels will increase as we move towards the mountains, which are mainly of granite.

The vegetation accordingly can be subdivided into the following groups:

5.2.1. Saline vegetation

Mainly dominated by ***Arthrocnemum spp.***, ***Suaeda spp.***, ***Juncus maritimus*** and ***Nitraria retusa***. Such vegetation is present in Ghor As-Safi, Ghor Faifa and in the Southern end of Wadi Araba, about 40 km N. of Aqaba (**Fig. 5.1**).

5.2.2. Tropical vegetation

Dominated by ***Calotropis procera, Acacia tortilis, Ziziphus spina-christi, Maerua crassifolia, Balanites aegyptiaca, Salvadora persica, Calligonum comosum*** and ***Ochradenus baccatus***. This type is highly affected by man either through the grazing of goats and camels or directly by cutting of trees for fire. If this vegetation is protected it will reach the climax within about 10 years. This vegetation is present in Ghor Faifa and Wadi Khnaizireh (**Figs. 5.2 & 5.3**).

Fig. 5.1. Showing the saline vegetation near Ghor Safi. This photograph was taken before the initiation of the Arab Potash Company.

Fig. 5.2. Showing elements of tropical vegetation: ***Acacia tortilis*** (lower), ***Ziziphus spina-christi*** (upper).

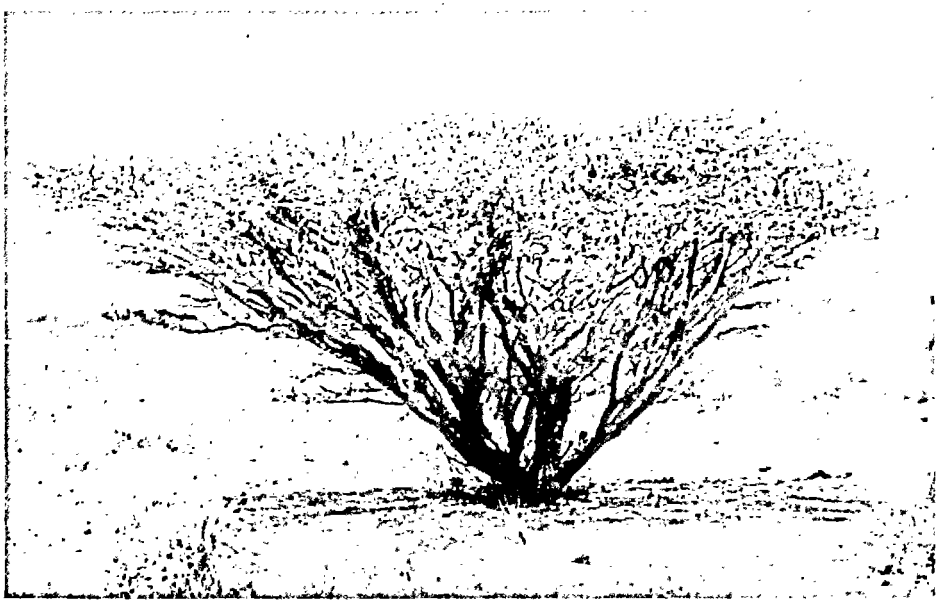


Fig. 5.3. Showing elements of tropical vegetation ***Calotropis procera***.

5.2.3. Sand dune fixatives

Dominated by ***Haloxylon persicum*** associated with ***Retama raetam*** and ***Calligonum comosum***. The shrubs of ***Haloxylon*** in some localities are about 3-4 m high and about 5 m in diameter. With such sizes this vegetation has reached its climax. The best locality of such vegetation is about 60-70 km N. of Aqaba along the road to Gharandal (**Fig. 5.4**).

5.2.4. Hammada soils vegetation

Usually dominated by bushes and low shrubs. The leading elements are: ***Anabasis syriaca, Traganum nudatum, Halocnemum strobilaceum, Gymnocarpos decandrum, Helianthemum lippii*** and ***Zygophyllum dumosum***. This type is present in most of the elevated rocky grounds in the Wadi.

5.2.5. Granite mixed soil

The vegetation associated with granite or granite mixed soils is dominated by ***Acacia tortilis*** which occurs mostly on firm hard soils. This leading element will be associated with other bushes or low shrubs like ***Anabasis articulata, Panicum turgidum, Lycium shawii*** and ***Hammada spp.*** The best habitat of such a vegetation type is the Eastern side of the wadi especially 30-35 km N. of Aqaba to the entrance of the city.

5.3. Wadi Shuaib

Wadi Shuaib is a water stream extending from the city of Salt in the East and extends down to the West to Shuneh South until it links with the river Jordan in the Rift Valley. It was named after the profit Shuaib who was barried at the high hills of the Southern side of the valley almost at a middle location of its length. The grave of this profit is still in its place were a mosque is built and lots of people visit it for religious purposes especially if they have promises to fulfill.

Wadi shuaib has been always an attractive place for visitors especially in the spring time due to the presence of water, lush of vegetation, beautiful countryside and changing in climate from cool in the high mountains to hot in the rift valley.

Fig. 5.4. Showing ***Haloxylon persicum*** as the main element in the sand dune vegetation type in Wadi Araba.

5.3.1. Physical aspects

The altitude in Wadi Shuaib varies from about 1000 m above sea level until it links with the Jordan valley at an altitude of about 350 m bellow sea level.

The temperature again varies from cool in the mountains to warm or very hot in the rift valley especially during the summer time. Often people visit or drive through Wadi Shuaib in winter times when it is very cold in the mountains to go to the rift valley where it is warm and pleasant. In fact sometimes it will be snow cover in the high mountains and one can drive from Amman to the rift valley passing through variable climate conditions of snow to the warm pleasant conditions in the rift valley in less than one hour.

The rainfall ranges from about 500 mm in the mountains to about 100 mm or less in the rift valley.

The soil changes from red terra rossa and yellow in the mountains to calcareous, sandy, alluvial, marls or saline at the outlet in the rift valley.

5.3.2. Vegetation

The vegetation of Wadi Shuaib can be recognized and subdivided into the following types according to the vegetation change with altitude. The best vegetation changes can be observed if one can go from Amman through Mahes, AL-Fuhais road (**Fig. 5.5**).

5.3.2.1. Forest vegetation

The vegetation is always a reflection of the topography and the physical aspects of the area. Therefore, the vegetation ranges from forest type in high lands around Salt area, Mahes and AL-Fuhais where evergreen oak forest ***Quercus coccifera*** is dominant then it becomes mixed with deciduous oak forest ***Q. ithaburensis*** and ***Ceratonia siliqua, Styrax officinalis, Amygdalus communis, Calycotome villosa*** until it becomes pure deciduous forest at a lower altitude and mixes with ***Retama raetam***.

In this part the forest vegetation is mixed by evergreen oak and deciduous oak forming a forest type named as mixed forest. This type occurs due to the humidity and the ability of the evergreen oak to extend its distribution into lower altitude where it mixes with other vegetation types especially tree form if present.

The land in this part is fertile and the rainfall is high in comparison to other parts in Jordan. Therefore, most of this vegetation type was destroyed for cultivation especially olive trees and in some cases with other stony fruits. In lower parts of Wadi Shuaib and close to the water stream some citrus fruits are cultivated especially lemon.

5.3.2.2. Shrub vegetation

Further down and at the borders of Mediterranean and Irano Turanean the vegetation becomes dominant by low shrubs and perennial herbs of ***Retama raetam, Anagyris foetida, Ferula communis*** and ***Fritillaria libanotica*.**

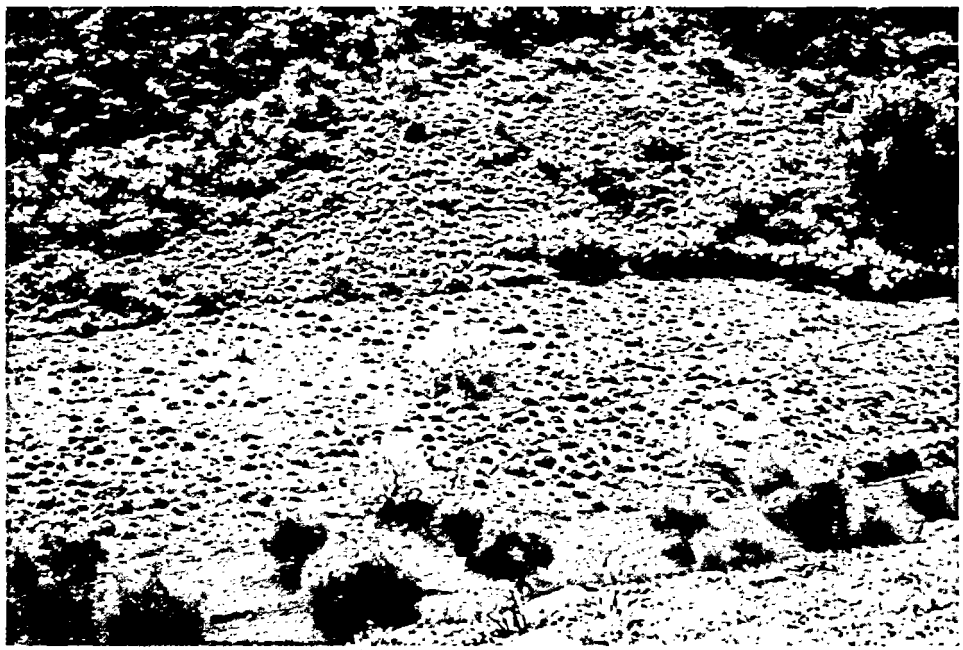
5.3.2.3. Bushes and herbs

This vegetation occurs in the calcareous type of soil forming a typical steppe vegetation in the Western slopes on the mountain ranges in Jordan. The same vegetation type can be observed more or less at the road from Karak to Ghor Safi just before sea level. The vegetation is covered by bushes and of ***Salsola vermiculata, Atriplex halimus, Trichodesma boissieri, Ferula communis, Urginea maritima, Sinapis alba.*** At about this level or even at the borders of the Mediterranean Irano Turanean ***Ziziphus lotus*** starts to appear. This species is considered by some as Irano Turanean element, but it has a more distribution in the cooler tropical areas.

5.3.2.4. Tropical vegetation

At about sea level altitude tropical vegetation elements start to appear and become more dominant in the Jordan valley (Rift Valley). The small shrubs of ***Rhus tripartita*** start to appear at the border level then further down bellow sea level other elements become more dominant such as: ***Calotropis procera, Ziziphus lotus, Z. spina-christi, Balanites aegyptiaca*** and ***Ochradenus baccatus.***

Fig. 5.5. Showing the vegetation type in Wadi Shuaib. Notice the dominance of ***Calycotome villosa*** and ***Retama raetam*** at the borders of Mediterranean and Irano-Turanian.



5.3.2.5. Water vegetation

This type extends along the water stream forming a thick cover in some places. The leading elements are: ***Salix sp., Phragmites australis, Arundo donax, Nerium oleander, Apium nodiflorum*** and ***Nasturtium officinale.***

5.4. Dana Reserve

Dana reserve is situated in the Southern part of Jordan at the borders between Tafila and Shaubak governorates. Is stretches from the high mountains in the East at about altitude of 1650 m down to the West in Wadi Araba at about an altitude of 200 m bellow sea level. It is characterised by having one of the most beautiful views and scenery in Jordan. The vegetation type is also unique since it is restricted to that part of the country.

Dana area and Wadi Finan are well known in the pervious history of Nabateans, Romans and Islamic civilizations of the region. It is famous as a close place to Petra and famous in having the copper mines and smelting sites for these previous civilizations. Until now there are still huge deposits of copper and manganese that can be used if needed. There were lots of plans and drilling studies to asses the feasibility of mining these deposits.

Due to the importance of this area and the unique structure of the vegetation ecosystem, Dana has been announced in 1993 as a natural national reserve under the supervision of The Royal Society For The Conservation Of Nature.

5.4.1. Physical aspects

Dana reserve is situated in a very critical place in terms of its location. It extends from the East mountain ranges with almost one of the highest points in Jordan (1650 m) down to the West in Wadi Araba at an altitude of about 200 m bellow sea level. Dana Reserve represents three out of four biogeographical regions in Jordan. These regions are Mediterranean, Irano-Turanian and Tropical. This variation allows huge variation and diversification in such a limited area.

This location is also critical since it represents the only forest vegetation ecosystem in Southern Jordan. One of the most critical characteristics of this position that, it is surrounded by almost a very dry ecosystems that make this reserve very important. It is bordered from the West by Wadi Araba a well known hot and dry area, and surrounded from the East after almost 10 km by the Eastern desert which is again a dry, hot ecosystem.

From the North a huge Wadi AL-Hasa makes another hot and dry ecosystem including the surrounding slopes. Finally the Southern part of the range mountains bordering the reserve are completely degraded from forest formation except from unprotected and badly degraded stand of evergreen oak shrub land ***Quercus coccifera*** between Shaubak and Petra near AL-Hisha and Bir Ad-Dabbaghat. After that the slopes are barren until they link with Wadi Rum which is again a very hot and dry ecosystem.

The rainfall ranges from 400 mm -50 mm from the mountains to Wadi Araba. Lots of snow falls yearly on the high mountains where the rain is scarce and the temperature is high in Wadi Araba. The Temperature represents the extremes from very cold winter and mild summer in the high mountains to warm and very hot summer in Wadi Araba. For example if the temperature in the high mountains is -5°C it will be 12-15°C in Wadi Araba during winter time, while in the summer time if the temperature is 25°C in the high mountains it will be around 40°C in Wadi Araba.

Soil type is almost linked to the parental rocks. Therefore, it varies from the high mountain where clayey soil at the top is the dominant with black, red or yellow types and then changes into sandy soil forming the majority of the soil types until reaching Wadi Araba. In some cases especially at lower altitudes when the sandy rocks disappear and then replaced by granite rocks the soil changes into mixed sandy-granite type. The sand soil becomes thick and accumulated to form sand dunes in some places.

The reserve is forming a rough terrain with a hidg degree of slopes reaching 50% or more in some places. In addition a wadi system with continuous water flow or seasonally wet is running across the reserve from East to West.

5.4.2 Vegetation

Since the reserve represents extreme differences in physical aspects and represents three different biogeographical regions, it is expected that the vegetation is highly diversified. During a vegetation and flora survey in the spring of 1994 I was able to identify 550 species recorded and collected from the reserve (RSCN, 1994). Some of these species are new to the flora of Jordan, some others are rare or endemic.

In general the vegetation of the reserve can be subdivided into three major groups as follows.

5.4.2.1. Mediterranean forest vegetation

In this type a low tree forest cover is the main type in the places with natural vegetation. This forest cover is dominated by evergreen oak forest ***Quercus coccifera, Crataegus azarolus*** and ***Pistacia atlantica*** on clayey soil and limestone parental rocks. When the parental rock changes into sand stone and thus soil becomes sandy Phoenician juniper ***Juniperus phoenica*** will be the dominant species. In some cases ***Juniperus phoenica*** is associated with ***Pistacia atlantica*** as the second leading species, in few other cases ***Pistacia atlantica*** is altered by ***Cupressus sempervirens***. The only place of natural occurrence in Jordan. In other cases the distribution of ***Quercus coccifera*** can spread lower to form a mixed vegetation with ***Juniperus phoenica.***

In association with the trees there are lots of shrubs, climbers, bushes and herbs such as ***Daphne linearifolia, Amygdalus korschinskyi, Cerasus prostratus, Osyris alba, Rubia tenuifolia, Lonicera etrusca, Globularia arabica, Origanum syriacum, Varthemia iphionoides, Artemisia herba-alba, Colchicum brachyphyllum, Crocus allepicus***.

5.4.2.2. Irano-Turanian steppe vegetation

This type is dominated by ***Retama raetam*** shrub in association with other herbs or bushes especially ***Helianthemum lippii, Diplotaxis harra, Artemisia herba-alba, Urginea maritima***. In some places ***Ziziphus lotus*** starts to appear as its upper limit of distribution in this area.

5.4.2.3. Tropical vegetation

The lower part of the reserve falls within the tropical territory of Jordan with a terrain varies from granite or sandy hill to more or less hammada type covered by small sized pebbles. This form the majority of this area until the land becomes dominated by a sandy nature with accumulation of sand dunes.

In the hilly firm type of soil *Acacia tortilis* is the dominant species in association with *A. raddiana, Ziziphus spina-christi* and *Ochradenus baccatus* especially around wadi beds and run-off places. In hot wet places *Phoenix dactylifera* and *Moringa peregrina* were observed.

In places with sandy soil and sand dunes Shrubs of *Haloxylon persicum, Calligonum comosum, Hammada scopira, H. salicornica, Traganum nudatum, Urginea maritima, Dipcadi erythraeum, Pancratium sickenbergeri, Leopoldia longipes, Neurada procumbens, Androcymbium palaestinum.*

5.4.2.4. Water (Hydrophytic) vegetation

Along water streams and water canal within the reserve typical water plant are found. The most typical species are *Salix babylonica, Populus euphratica, Tamarix spp., Nerium oleander, Arundo donax, Phragmites australis, Typha domingensis, Equisetum ramosissimum* **(Fig. 5.6)**.

Fig. 5.6. Showing water vegetation in Wadi Finan, Wadi Araba.

5.5. Azraq Basin

Azraq basin is part of the major Eastern desert of Jordan classified earlier in this work as the Saharo-Arabian region. The total area of Azraq basin is about 12,000 sq. km. The basin has been studied previously by different expeditions or scientists (**BAKER & HERZA,** 1958; **BOYD** 1964 &1966, **GARRARD et al.,** 1985; **HEMSLEY & GEORGE,** 1966; **HOLLOM,** 1956; **MOUNTFORT,** 1963 & 1965; **NELSON,** 1973).

Since Azraq basin is covered as part of the desert region, the concentration here will be made on the Azraq Oasis especially the Wetland Reserve. Azraq Oasis is about 90 km E of Amman situated in the Eastern Desert (The Badia). This region is characterised by hot long summer and cold winter with little rainfall, yet the occurrence of such a wetland in the heart of the desert has created a very unusual lively ecosystem in an unexpected hostile environment.

The presence of Azraq Oasis is a miracle for the survival of many plant and animal species. Recently a new study was carried out to survey the flora and the vegetation of the wetland reserve (**AL-EISAWI,** 1995) where most of the following information was obtained.

5.5.1. Physical aspects

5.5.1.1. Topography

Azraq Oasis wetland is part of the larger Azraq basin. The whole area is more or less flattened forming a depression in the desert as extended into the Azraq Mud flat (Qaa' AL-Azraq). Since it is more depressed than the surrounding places, it forms a structure like a huge concave plate. The altitude in the Eastern desert in general ranges from about 500 - 700. In some cases it exceeds the range limit where it becomes 480 m in Gublan AL-Hazeem and 1225 m the maximum limit as it is in the Northeastern part at the borders with Syria, where it is about 1000 m or more.

In Azraq Oasis the altitude is about 520 - 522 m, where it forms a low depression in comparison with the surroundings.

5.5.1.2. Rainfall

The rainfall of the Eastern desert of Jordan ranges from 50-100 mm per year and rarely exceeds such ratios. Azraq wetland reserve almost in the centre of the Jordan badia, Therefore, the rainfall in this area will be logically almost the mean between the two mentioned ranges.

During the period 1962-1971 the mean rainfall was 73.5 (**NELSON,** 1973). The rain was mainly fallen within the period between the months of October and May.

The mean annual rainfall for Azraq during the period of 1966-1980 was 69.9 mm (**AL-EISAWI,** 1985).

In comparison to the above mentioned numbers of rainfall the records of the Department of Meteorology, Amman, Jordan, the mean annual rainfall for the period of 1981-1992 was 67.8 mm. The months of rainfall were ranging from September to May.

5.5.1.3. Temperature

In general the temperature correlates with rainfall, Therefore, if we consider the rainfall for the same period 1962-1971 we will find that the rainy months have the least grades of temperature and visa versa. The maximum temperature recorded in the period 1962-1971 was 45.5°C in July 1968, while, the minimal temperature was (-1.7°C) in January 1966.

The mean maximum temperature recorded for the period 1966-1985 was 36.3°C, while the minimum temperature recorded for the same period was 2.6°C (**AL-EISAWI,** 1985).

Recent records obtained from the Department of Meteorology for the period 1981-1992, show that the mean maximum temperature was 26.4°C, while the mean minimum temperature was 11.8°C. The maximum temperature recorded for the same period was 45.0°C in August, while the minimum temperature was (-5.4°C) in December and January.

5.5.1.4. Soil

The Eastern desert of Jordan is characterized by having a dominant soil type called hammada. This soil type is mostly clayey and covered by gravels or pebbles. Azraq basin is characterized by having alluvial soil type transported by wind or water. The soil is mostly clayey loams or silty loams.

The parental rock is of limestone type withering into soil rich in calcium carbonates. Nevertheless the whole basin is still rich in gypsum deposits which after withering add to the texture of the soil component.

In addition to these major components, the soil of the basin and the wetland is highly rich in salt dominated by sodium chloride. In flooding times the soil becomes very sticky, gray in colour and difficult to move around.

Soil around the water pools and water bodies is rather rich in organic matter due to decomposition of dead particles of biological components. Accordingly often the soil colour looks very dark and the smell of methane gas can be detected.

5.5.1.5. Hydrology

The water of Azraq Oasis is an accumulation of both surface water and deep subsurface water.

The origin of the surface water is that Azraq wetland reserve and the attached Qaa' AL-Azraq are forming a low depression in comparison with surrounding areas. This depression is connected with inlet of wadi systems that charge their flooded water into the basin during the rainy season. It is well known in the desert areas that rain occurs in heavy floods in a very short time. Sometime 80% of the registered water can fall within few hours of one day. Such huge amounts of water will accumulate very fast in such depressions as Azraq, and thus have no time to be slowly absorbed by the soil surface.

It is believed the major water body as an aquifer and accumulated in the water pools of Azraq Wetland is gathered from the rainfall on the mountains of the Syrian desert. It is reported that mountain of Jibal AL-

Arab South of Syria receives about 1200 mm of rain every year. Great amount of this rain is filtered to the underground layers where it accumulates in Azraq basin.

The quality of the water in Azraq wetland varies from potable to a brackish water. the total dissolved solids (TDS) range from 320 ppm to 1376 as recorded by **NELSON** (1973). Few Samples were taken during this study from flooded areas of the wetland have recorded a TDS number exceeding 5000 ppm. This is expected after few years of total drought with no water floods at all and continuous accumulation of salts due to evaporation and no chance of leaching.

5.5.2. Vegetation

The vegetation types within the Wetland Reserve can be classified into three main divisions:

1. Dry land vegetation dominated by silt dunes.
2. Wetland vegetation.
3. Grassland vegetation.

5.5.2.1. Dry land Vegetation

The dry land vegetation in Azraq Wetland forms the majority of the total area of the reserve. It is dominated mostly by dome like silt dunes occupied mostly by ***Nitraria retusa*** or rarely ***Tamarix passerinoides, Aeluropus littoralis, Juncus maritimus, Nitraria retusa, Alhagi maurorum, Frankenia hirsuta, Halopeplis amplexicaulis*** **(Fig. 5.7)**.

This type of dry land vegetation can also be subdivided into three different subgroups as follows:

5.5.2.1.1. Silt Dunes

This type is dominated by ***Nitraria retusa*** and ***Tamarix passerinoides.*** The change in dominance and leading species in term of abundance alternate based on the type of silt dunes in relation to water availability. It was clear that ***Nitraria retusa*** becomes more dominant in dry places, while ***Tamarix passerinoides*** becomes more dominant in the places with more humidity and when water table is higher **(Fig. 5.8)**.

Fig. 5.7. Showing dry land vegetation in some places of Azraq wetland reserve. Notice the plants of ***Alhagi maurorum*** (upper) and ***Halopeplis amplexicaulis*** (lower).

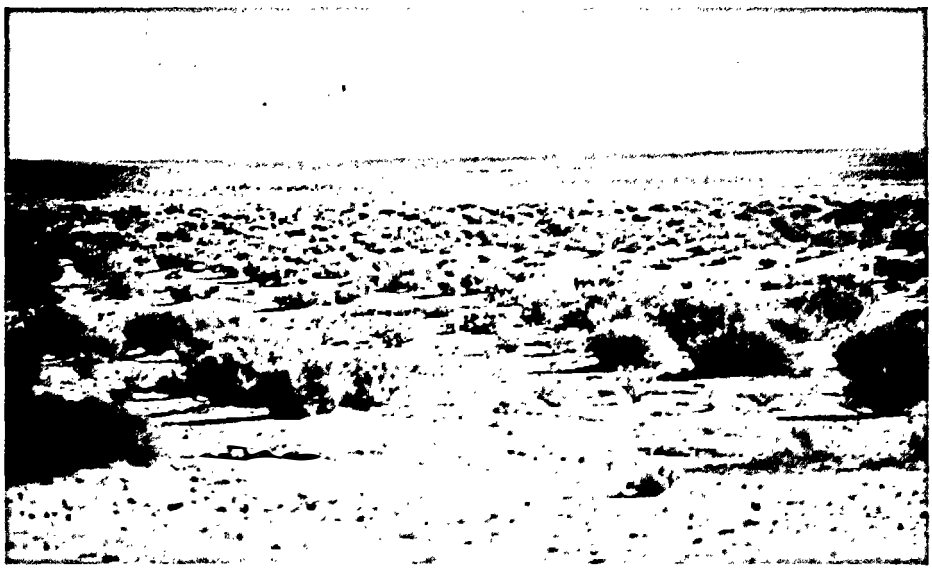


Fig. 5.8. Showing silt dunes occupied by ***Nitraria retusa*** and ***Tamarix passerinoides***.

5.5.2.1.2. Rocky Limestone Vegetation

This is a subdivision of the dry land type of vegetation where suddenly an area of about 100-200 m^2 is occupied by a different vegetation type dominated by two main species ***Limonium meyeri*** and ***Inula crithmoides.*** In some other places they were associated with ***Halocnemum strobilaceum.***

5.5.2.1.3. Qaa' Border Vegetation

This type of vegetation is occurring as a result of the retreat of water from the flooded areas to the Qaa'. In the parts dominated by soft clayey or silty ground the vegetation will be dominated mostly by ***Halopeplis amplexicaulis, Suaeda asphaltica, Tamarix passerinoides*** and ***Aeluropus littoralis.*** When moving closer to the Qaa' then soil becomes more firm, the leading species will be ***Tamarix passerinoides*** and ***Halocnemum strobilaceum*** until we reach a pure stand of vast area of vegetation of ***Halocnemum strobilaceum*** **(Fig. 5.9)**.

5.5.2.2. Wetland Vegetation

In Azraq there are two distinct water plants associations occur as a result of the water salinity quality, although they are within the reserve boundaries. But if one looks at the vegetation structure in terms of plant species composition one can realize the difference. This is exactly reflected by the soil test analysis and the water analysis. Accordingly, two subgroups can be recognised as follows:

5.5.2.2.1. Fresh Water Vegetation

This type of vegetation is restricted in the main place of the permanent water pools near AL-Qaisieh and As-Sauda, where the water is usually potable due to the low amount of salinity. The TDS rarely exceeds 500 ppm. In fact few years ago they were the main point of the water pumping station to Amman. Due to that the dominant species are ***Typha domingensis, Phragmites australis, Juncus acutus, J. maritimus, Imperata cylindrica, Sonchus maritimus*** and ***Inula crithmoides*** **(Fig. 5.10)**

Fig. 5.9. Showing saline vegetation at the borders of the Qaa' becoming almost a pure stand of ***Halocnemum strobilaceum*** at the Qaa' edge.

Fig. 5.10. Showing fresh water vegetation near the main pools in Azraq South (Shishan). Notice the thick stand of ***Typha domingensis***.

Phragmites australis is considered as the primary invader for the water then preceded by ***Typha domingensis***. At the end ***Typha*** forms pure stands as rooted plants in the water body, then followed by ***Phragmites, Imperata, Juncus acutus*** and ***Tamarix amplexicaulis*** usually at the borders of the water body.

5.5.2.2.2. Brackish Water Vegetation

This type of vegetation forms the penetration of the water canals and water bodies that are flooded occasionally and dried later on the season. The water of such water bodies is highly saline. More than one sample of water were taken during the survey have indicted very high values of TDS exceeding 5000 ppm.

Accordingly the vegetation was dominated mainly by almost total growth of ***Chara sp., Ruppia cirrhosa, R. maritima, Zannichellia palustris*** and ***Scirpus maritimus***. Sometimes shrubs of either ***Tamarix tetragyna*** or rarely ***T. passerinoides*** are found in the water bodies **(Fig. 5.11)**.

In Inglesi water canal the water quality was apparently less saline than others but still brackish, Therefore, an aquatic flowering plant ***Ranunculus aquatilis*** was floating in massive batches.

The dominance of ***Scirpus maritimus*** varied from place to place. In some places it was almost filling the whole water body, but in some other places it was very few. In general in narrow, shallow and saline canals the ***Scirpus*** was forming a pure stand of rooted aquatic plants, with ***Chara sp., Zannichellia palustris*** and ***Ruppia cirrhosa, R. maritima*** filling between the stems in the water.

The margin of the water bodies was always dominated by ***Tamarix tetragyna*** or ***T. amplexicaulis*** and rarely with ***T. passerinoides***. This is in association with ***Phragmites australis, Juncus maritimus, Lythrum tribracteatum, Aeluropus littoralis, Spergularia salina, Halopeplis amplexicaulis*** and sometimes ***Asparagus sp.*** especially around the Inglesi water body.

If one samples the plants few meters away from the water body typical dry plant vegetation will be dominant especially ***Alhagi maurorum, Cressa cretica, Nitraria retusa*** etc.

5.5.2.3. Grass land Vegetation

Grass land vegetation covers a vast area of the flooded land especially in the West and Northern west part of the wetland reserve. Most of the vegetation forms bog that has been filled with organic matter of previous vegetation and some soil particles. In some part and during the flooded season it is rather dangerous to walk through because one can easily sink to his half in different places expected to be firm and hard in outer looking, but in reality it is a fluffy spongy like structure on top of a huge water body **(Fig. 5.12)**.

Most of that area is considered to be filled with a type of compost material, similar to peat moss but rather different in nature since the moss species like ***Sphagnum*** does not grow in Jordan especially in such a saline condition.

However, the vegetation is dominated mostly by a single species that is ***Phragmites australis*** associated with other annual plants such as ***Polypogon monspeliensis, Spergularia salina, Juncus bufonius, Sonchus oleraceus*** and ***Suaeda asphaltica*** or some perennial sedges dominated by ***Juncus maritimus, J. acutus***.

Fig. 5.11. Showing brackish water vegetation especially during flooding season. Notice water vegetation that will be filled eventually by a thick stand of ***Scirpus maritimus***.

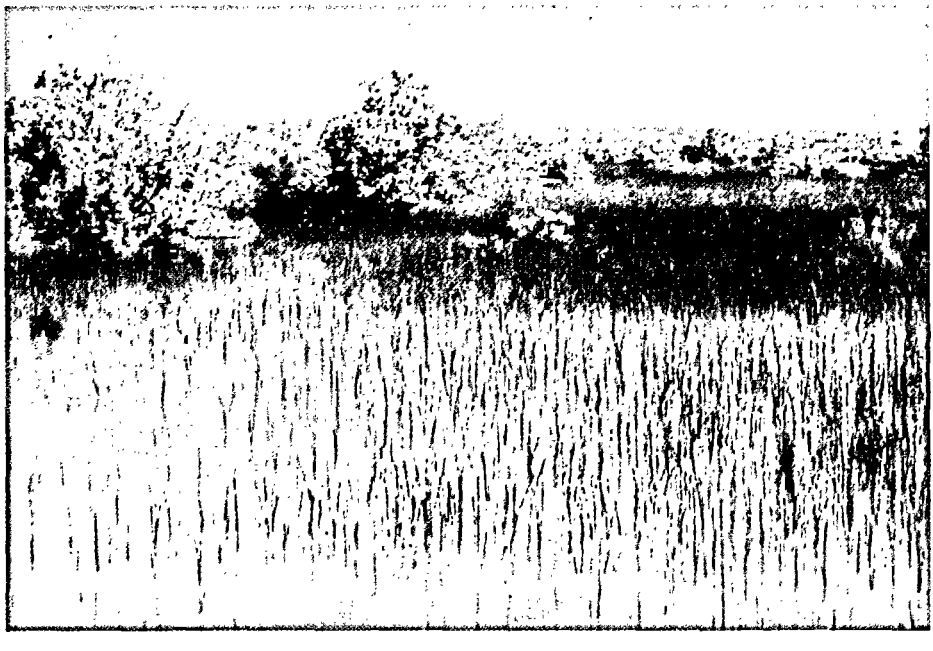


Fig. 5.12. Showing a huge area near the fresh water pools where the land is soaked with water and the vegetation is dominated by ***Phragmites australis*** associated with other annual plants such as ***Polypogon monspeliensis, Spergularia salina, Juncus bufonius***.

5.6. Shaumari Reserve

Shaumari reserve is located about 100 km East of Amman in the Eastern desert. It was initiated by the Ministry of Agriculture in 1958 as a range land reserve. It was then taken over by the Royal Society for the Conservation of Nature (RSCN) in 1968 where it was used effectively as a centre for the wildlife protection and for rehabilitation of the extinct Oryx from Jordan. The reserve is about 10 km South of Azraq, off the main road leading to Saudi Arabia.

Shaumari reserve is considered as an important example about natural protection in general and as a living pattern for the protection of the dry ecosystem in particular. It can be used as a special station to study the wildlife of the dry ecosystem in terms of: diversification, speciation, physiology, adaptation, behavior and evolution.

Shaumari can be used as a complete biodiversity station since it has both native animals and natural vegetation without much interference of human. This reserve is a bright and an actual model to show how much protection is important for the conservation of nature. However, it is needless to say anything to convince people about the importance of the protection of nature, it is enough to take people just to visit this reserve and to observe the difference inside and out side the fence.

A report about the management of wildlife in the reserve was produced by **CLARKE** (1978). In the period of 1980-1990 scientific research was carried out on the reserve to study the vegetation ecology (**AL-EISAWI & HATOUGH,** 1987), the behavior and adaptation of the Arabian Oryx (**HATOUGH & AL-EISAWI,** 1988) and the rodent ecology (**HATOUGH & AL-EISAWI,** 1990).

5.6.1. Physical aspects

5.6.1.1. Topography

The total area of Shaumari reserve is 22 sq. km., with an altitude ranges from 530- 550 m. It is part of the main Azraq basin with more or less flattened land with a net work of wadi system. The wadis vary in depth and width which affect the amount of water movement and thus the vegetation.

The reserve is double fenced with 20 meters apart from each other. The external is made of barbed wire fence and the internal fence is made of net wire, similar to that used in tennis yards.

5.6.1.2. Rainfall

The annual amount or rainfall in the reserve area ranges from 50 -100 mm. This rain is very little and very irregular. The whole amount could fall in few days of a single month or sometimes 90 % of the yearly rain could fall in few hours.

The wadi systems in the reserve are often flooded yearly from the heavy casual thunder storms. Therefore, huge amount of water is accumulated in the reserve, which has been collected recently as a surface water harvesting, that lasts for a long period during the summer.

This water is used as a natural drinking water for the animals, and has provided a thick vegetation for the animals to hide, especially during birth and nursing of youngsters.

5.6.1.3. Temperature

Temperature in the reserve varies from winter to summer time. The desert is well known for the very cold nights during the winter period. The lowest temperature during winter could go down as - 10 C°, while the maximum temperature could go up to 40 °C or more. But in general the winter is cold and the summer is rather mild in comparison to that of the Saudi Arabia or the Gulf States. The mean annual minimal temperature was found to be 2.6 °C, while the mean maximum temperature is 36.6 °C (**AL-EISAWI,** 1985).

5.6.1.4. Soil

During the vegetation survey (**AL-EISAWI & HATOUGH, 1987**) a soil map prepared by **HAMSELY & GEORGE** (1966) based on the work of **BAKER & HERZA,** (1958) was adopted. The map has classified the reserve into three association as: limestone-hammada, saline-gypsum and alluvial.

5.6.2 Vegetation

Based on the prevailing temperature and the rainfall season, the vegetation period starts almost at about mid March to early April. Often the vegetation is very rich correlated with rainfall quantity and on the winter season. But in general the spring time does not last more than two months at most.

Most of the plants growing in the spring time are short living annuals or ephemerals adapted to finish their life cycles in a short period. The main bulk of the vegetation is composed of desert bushes or low shrubs that have reached almost their climax. Such plants are well adapted to the dry hot summer and most of them have their vegetative season during the summer. Accordingly, many of these bushes or shrubs are either succulent or spiny as the best morphology to adapt to the dry, hot and saline habitat.

Thick shrub vegetation have reached about three meters in height and have provided a special micro climate conditions that enabled some Mediterranean elements to grow in the reserve. In fact this thick vegetation have provided an excellent place for the Oryx to hide. The Oryx has made bed like ditches at the base of these shrubs to be used as birth sites, hiding and nursing their youngsters. Such ditched were only on at one side of the shrubs, then later were extended to be as a ring ditch around each shrub (personal observation).

In general the vegetation of Shaumari Reserve is subdivided into four subgroups as follows:

5.6.2.1. Hammada type

This type is restricted to the part of the reserve that is covered by gravel nature. The soil is firm and reddish in colour with sparse vegetation cover not more than 10 %. The species in this type is the low shrubs of ***Seidlitzia rosmarinus*** followed by ***Anabasis articulata***. Other species were observed such as: ***Atriplex halimus, Astragalus spinosus, Carrichtera annua, Gypsophila arabica, Aizoon canariense, A. hispanica, Mesembryanthemum nodiflorum.***

5.6.2.2. Mud flats vegetation

This type is a rather restricted to the small Qaa' like area resulted from the water accumulation after drying. It is a highly compact area with a very poor vegetation except on the margins. The most dominant species is ***Capparis leucophylla*** followed by ***Ephedra transitoria, Hyoscyamus muticus, Atriplex halimus, Artemisia herba-alba.***

5.6.2.3. Saline vegetation

It is again a restricted part of the reserve dominated by soft soil rich in gypsum and sometimes with salt crusts. The dominant leading species is ***Nitraria retusa*** followed by ***Limonium pruinosum, Reaumuria alternifolia, Suaeda vermiculata, Alhagi maurorum.***

5.6.2.4. Run-off vegetation

This type comprises the majority of the vegetation in the reserve. About two third of the reserve is well covered by bushes, shrubs and herbs with a total cover reaching about 100 % in some places.

The dominant leading species are the shrubs of ***Atriplex halimus*** with an extensive herbal cover of ***Phalaris minor, Lolium sp., Hordeum glaucum, Carrichtera annua, Vicia peregrina, Atriplex leucoclada, Artemisia herba-alba, Polygonum equisetiforme, Ephedra transitoria, Deverra tortuosa.***

6. BIODIVERSITY

6.1. Definition

6.2. Importance

6.3. International Causes of Biodiversity Loss

6.4. Causes of Biodiversity Loss in Jordan

6.5. Biodiversity as important genetical resource

6.1. Definition

Biodiversity is the number of living organisms (Plants, Animals, Fungi, Microorganisms) and their interaction in the ecosystems. Such collections of living organisms and ecosystems have formed the major terrestrial and aquatic biotopes. Therefore, the tundra ecosystem comprises a set of plants, animals and microorganisms different from those occurring in the tropical ecosystem or the desert ecosystem. Similarly, marine ecosystem of the warm sea is different from the marine ecosystem of cold sea. Due to that, the distribution of the beautiful coral ecosystem became restricted to certain areas of the universe. Again a fresh water ecosystem has organisms totally different from sea or brackish water. Mangrove plants occur along the sea water and can tolerate a high concentration of salinity. Contrary to that reeds and cattails plants grow only around fresh water.

As a result of that, the organisms living in a particular area occur as a reflection of the physical factors (rainfall, temperature, soil, altitude, wind, etc.) prevailing in that area. Although, some organisms occur in more than one geographical area, yet each population have different sets of characters to be able to occur specifically in such a specific location.

On this basis, there are species that do not occur anywhere else except in that area. Such plants are endemic species.

If we talk about Jordan, then the biodiversity is the total number of species (plants, animals and microorganisms) occurring in Jordan and forming the different biogeographical regions in relation to our local physical environmental conditions.

Jordan is divided into four biogeographical regions (**Map 3.3**):

i. Mediterranean region
ii. Irano-Turanian region
iii. Saharo-Arabian region
iv. Sudanian or Tropical region

These regions in Jordan have different biological diversity elements. Similarly, other parts of the world have other elements. But unfortunately, there is a very speed process of destruction of these precious biological

resources through excessive irrational use of such limited resources by the greediest biological creature, the Human Being.

6.2. Importance

The Components of the biodiversity are most valuable for human being since they are the main source of our food medicine, shelter, industrial products, crops, ornamental plants, birds, main source of the oxygen we breath, the main elements which are able to clean the air for excessive CO_2, and reduce global warming, the major source of our rain, fixing the soil, recreation and tourism etc.

If one would express the importance of biodiversity in numbers, it was estimated that 4.5 % of the gross domestic products in USA was worth $87 billion in 1970s. Fisheries based on wild species contributed about 100 million tons of food worldwide in 1989. Trade in agricultural products amount to $3 Trillion in 1989 (**GLOBAL BIODIVERSITY STRATEGY**, 1992).

Once, all medicine came from wild plants and animals. In China about 5000 species are used in Chinese traditional medicine. Nearly 2500 species of medicinal plants have been used in the Soviet Union. The Amazon people have used more than 2000 species of wild medicinal plant. Arab culture was and still very famous in the use of wild medicinal plants (**GLOBAL BIODIVERSITY STRATEGY**, 1992).

It is very clear that the biodiversity components are very important and every single human being should work hard to conserve and use sustainably such very important natural resources, because they are for us as well as for future generations to come.

6.3. International Causes of Biodiversity Loss

The variety of biodiversity species, ecosystems and habitats influence very much the productivity and the service provided by the ecosystem to humanity. As a series of changes started to take place, the ecosystem will be unbalanced and thus a series of species extinction will start to take place. In natural order every thing is in balance due to the natural

interaction between organisms. But since human started to over exploit his resources it was very difficult to maintain this natural equilibrium, and thus most ecosystems now are observing variable degrees of destruction an species extinction and therefore, loss of biodiversity. The causes of biodiversity loss can be summarized as follows:

6.3.1. Increase in population, habitat loss and fragmentation

Due to the enormous increase in human population and the urgent need for food, lots the forest land and natural habitats have been destroyed for cultivation. It is enough to say that the population has doubled within the past 50 year and expected to double by the year 2025.

6.3.2. Introduced species

Introduced plant or animal predator species have caused the extinction of many species. This is very true especially in islands which have many endemic species where introduced species have really caused the disappearance of such endemic species which do not occur in other parts of the world.

6.3.3. Over exploitation of plant and animal species

Numerous natural resources such as forests, rivers, lakes, animals, wildlife in general have come to the point of extinction. Hunting in Arabia has caused the extinction of the Oryx and Gazelle from the Syrian desert and the Arabian Peninsula. Such animals have been introduced to their natural habitat after being brought from captivity in International Zoo Parks. The African animals such as Elephant, Rhino, Buffalo and many others are at the verge of extinction due to this exploitation. Due to that, CITES has been formulated to forbid the trade with rare, endemic and endangered species. This can be applied to the over exploitation of medicinal plants in the Indian Peninsula, China and other parts of the world.

6.3.4. Pollution of soil, water and air

As a result of the advancement in the industry especially in the Western world, lots of pollutants have been emitted or discharged to the ecosystem. Acid rain is caused by the fumes produced by the chimneys of factories. Dead fish and other biological species were resulted of waste

chemical discharge in these ecosystems. Nuclear waste and radiations have affected many aquatic and terrestrial organisms.

6.3.5. Global climate change

Global climate changes have caused the destruction of some ecosystems and loss of biodiversity. Ozone depletion is one of these elements which is affecting many organisms and altering their genetic make up. Famine in Africa was due to the shortage of rainfall and thus loss of crops and domestic animals. Greenhouse effect and global warming is one of the most serious issues threatening the biological diversity and human being.

6.3.6. Industrial agriculture and forestry

Due to the high demand on food man started to work on the increase of crop products by many methods. Some where based on selection of genetical varieties of high yield, others invented variable range of chemicals to combat pests and diseases. Such chemical compounds have proved to be very dangerous on the living organisms of the ecosystem. In fact new mutations of insects resistant to the pesticides have evolved which are more harmful to nature. Lots of the useful species have disappeared due to such activities.

6.4. Causes of Biodiversity Loss in Jordan

6.4.1. Increase in population, habitat loss and fragmentation

In Jordan the fertile soil that was covered by forest is estimated to be less than 10% of the total area. The total population of Jordan has increased from 0.40 million in 1945 to 4 million in 1993 in fifty years.

It is clear that the population has increased ten times, at the same time the total area of forest in Jordan has decreased more than ten times.

This huge increase was definitely at the expense of the biological diversity and at the expense of the limited forest area. This loss has been associated with the extinction of various species occurring in Jordan especially Orchids.

6.4.2. Introduced species

Introduction of new crops to cultivated was at the expense of forest or grazing land. Lots of wild species were lost. In addition, lots of weeds have spread very fast to overcome the natural vegetation. In the Jordan Valley, the natural vegetation is tropical or subtropical, but due to the spread of cultivation, weeds have replaced the natural vegetation and lead to the loss of biodiversity.

6.4.3. Over exploitation and forest destruction

Over exploitation of plants in Jordan as being collected from the wild has led to the extinction of many species. Sage was recorded to grow wild in Jordan. It was not possible to collect any specimen from the wild within the past 20 years. Therefore, the cultivation of this plant may help to distribute this important species to the wild.

Similarly, destruction of forests in Jordan and the use of land for farming or houses has led to the disappearance of many rare Orchid species in Jordan. Such orchid species do not occur in the wild except under forest ecosystem. It is inevitable to say that the destruction of plant or animal habitats will definitely led to their loss and extinction.

In Jordan the Arabian Oryx has been totally wiped out to the verge of extinction due to the hunting process. In late 1970s the Royal Society for the Conservation of Nature has reintroduced few heads to Shaumari Reserve (**Fig. 6.1**). This herd in Jordan is one of the largest in the world. The total number exceeds 160.

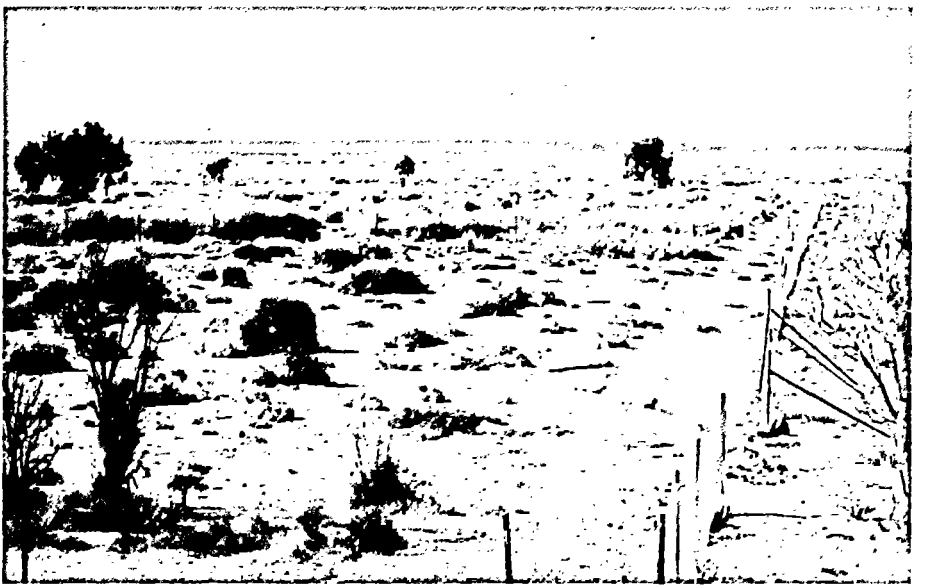
Azraq Oasis is a striking example of human over exploitation. Over pumping of the fresh water for human use, from such a beautiful place in the hot desert has led to the dryness of this wet land. This dryness has automatically led in just few years to the destruction of the ecosystem, and thus the loss of rare well adapted biological elements, including rare fish, plants and amphibians. In addition, this oasis was used by migratory birds as a natural station during their trip from Northern Europe to Africa. Few years now no birds come to this unpleasant, dry place (**Fig. 4.44**).

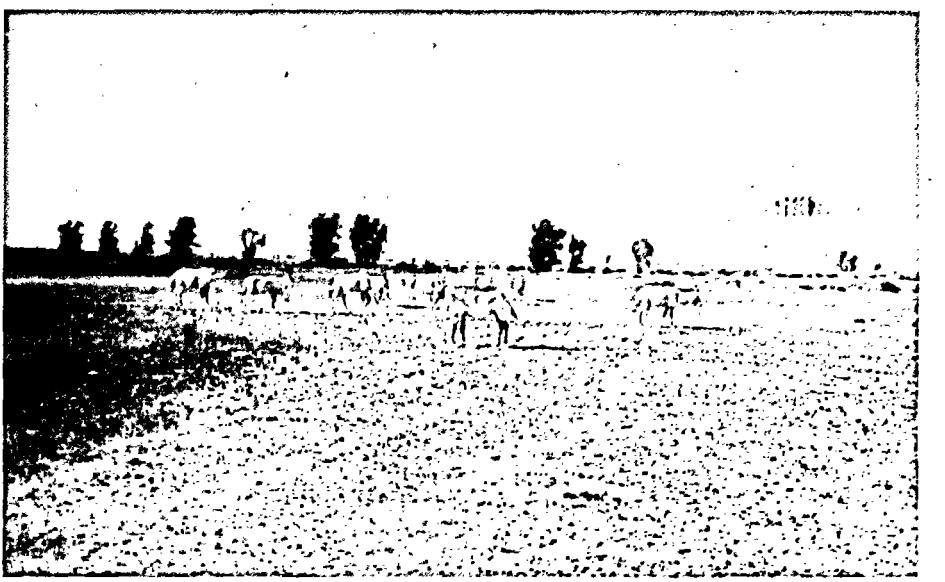
6.4.4. Pollution of soil, water and air

Pollution through the advancement of industry during the past few decades has led in many parts of the world to severe loss of biodiversity. In Jordan the Zarka river, called now as Sail Az-Zarka is passing through Amman down to Jarash then to Jordan Valley to meat the River Jordan. This river fifty years ago people were drinking its water. Now, the water sometimes especially during the summer time, when no rain water to dilute pollution, water is suspected for the use in agriculture. As a result of the foundation of many industries along this river, lots of pollutants are discharged directly into the river water. Some of these pollutants are heavy metals, stains, detergents, oil, etc. Such pollutants have killed many organisms and plants in this fresh water ecosystem. Even water quality, colour, taste, contents have been badly altered and spoiled to be effective for the benefit of local people.

Accordingly, there is a continuous check on the water quality of King Talal Dam, where water accumulates to decide if the water is good for human use other than drinking. It was hoped that this water would be used of drinking and domestic human use, especially when Jordan is in bad need for such a valuable resource.

Fig. 6.1. Showing Shaumari Reserve (upper), and Oryx animals, reintroduced to the reserve after being extinct in the area (lower).





6.4.5. Effects of man activities on forest ecosystem and loss of biodiversity

Over the past 40 years highly pronounced factors causing forest biodiversity loss are highly affected Jorda.ı as a result of man impact. The followings are some of these factors:

1. The population has increased within the past fifty years about ten folds.

2. Location of the population majority (90% of the total population) is concentrated in a limited part of the fertile land. In fact the spread of the cities and rural areas was in the mountains at the expense of the forests.

3. The need for food has increased to match the population causing immense pressure on the fertile land and the destruction of forest remnants in Jordan.

4. Destruction of forest land has reduced the amount of atmosphere humidity subsequently the reduction of rainfall year after year.

5. The increase of population associated with the decrease of rainfall has caused increased demand on water especially clean drinking water and industry water need. In fact the **NATIONAL ENVIRONMENTAL STRATEGY** (1989) shows that Jordan will suffer from water deficit at the beginning of the new century (at the year 2000).

6. Forest destruction, grazing, decrease of rainfall ɔvɛrl caused soil erosion in the mountain areas, in fact desertification has occurred in previous forests land which is unusual **(Fig. 6.2)**.

7. Destruction of ecosystem and extinction of biological resource. To illustrate this phenomenon, the following examples are given to demonstrate this dangerous thing:

a. There are 24 species of Orchids recorded in Jordan **AL-EISAWI** (1986). Unfortunately, most of those orchids occur under forest vegetation. Therefore, all of these species are classified as endangered species. It has been proved that some species have not been recorded since

1945. Others are known only from one small locality. One genus ***Anacamptis*** is considered extinct in Jordan. A specimen of this genus was collected from Jordan in 1886 and deposited at the Natural History Museum, London. A photocopy of that specimen is deposited at the Herbarium, University of Jordan, Amman **(Fig. 6.3)**.

b. Many other species occur under the forest vegetation in Jordan are at the verge of extinction and need very special attention, examples of these are: ***Salvia triloba, Narcissus tazetta, Vinca herbacea, Opoponax hispidum, Scandix palaestina, Smyrnium connatum, Smyrnium olusatrum, Sternbergia colchiciflora, Cupressus sempervirens*** (the wild plants), ***Viola pentadactyla, Viola modesta, Arabis aucheri, Arabis nova, Arabis verna, Hesperis pendula, Iris vartanii, Iris atrofusca, Crocus hyemalis, Crocus hermoneus, Colchicum stevenii, Tulipa stylosa, Tulipa agenensis.***

Lots of these plants in addition to being rare they are highly admired by people and often picked. Unfortunately, there is no law until now to forbid picking and protect these plants.

c. Some of the animals and birds used to occur in the cleared forest areas have been recorded to be extinct or endangered. The fallow deer ***Dama mesopotimica*** which used to occur in Jordan has been reintroduced back to Jordan in Zubia Reserve after being extinct and brought from Turkey.

8. Finally Jordan is a developing country with limited resources and limited technical ability. Nevertheless, it is very critical to protect what is left from the forest and to formulate new legislations to protect endangered and rare species. In fact the government and private organizations are very active at the time being in Jordan. Based on that quite good number of reserves have been established during the past few years, two of them in the mountain regions.

Fig. 6.2. Showing vegetation degradation and soil erosion at the Western side of Karak-Tafila Mountains towards Wadi Araba, near Khanaizerah-Wadi Araba.

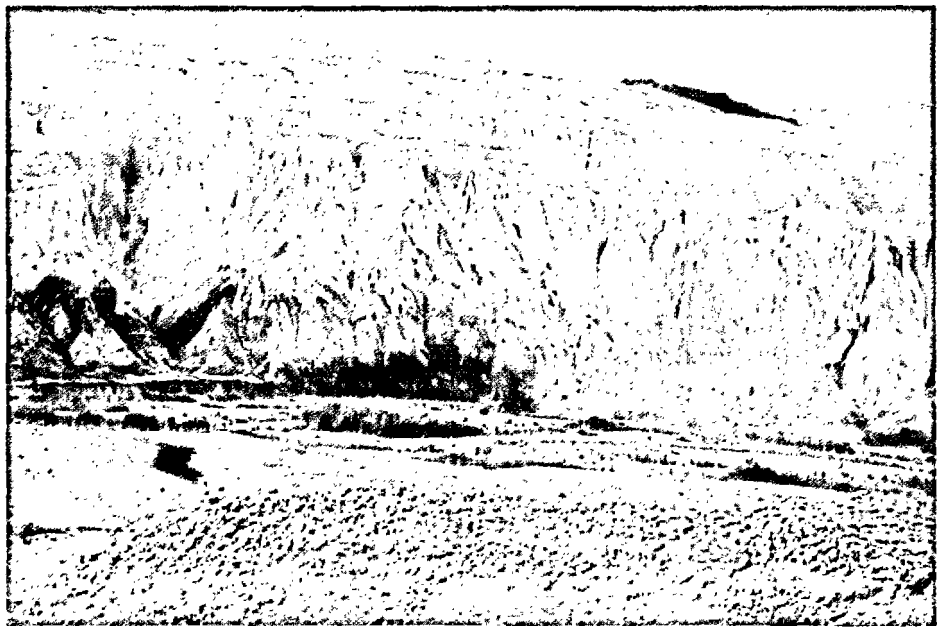


Fig. 6.3. Showing extinct Orchid species ***Anacamptis pyramidalis***, collected from Jordan, more than 100 years ago (May, 1886), from Jarash-Burma. This specimen is deposited at the Natural History Museum, London-UK.

6.5. Biodiversity as Important Genetical Source

The importance of biodiversity in Jordan as a national heritage of genetical resources that can be used for the human kind benefit will be highlighted as follows:

6.5.1. Forests and trees

Under the natural conditions of Jordan, classified as a dry country, there are four major types of forests grow, these are:

i. Pine forest
ii. Evergreen oak forest
iii. Deciduous oak forest
iv. Juniper forest

Such forest ecosystems in Jordan are the most important elements in the Mediterranean region. They are responsible for the quality of fresh air we respire; for absorption of CO_2, other air pollutants and reduction of global warming; for the rainfall we have; for the fertile soil used in cultivation; for the beauty and general appearance of the sight seeings and recreation areas; for fixing the soil and avoiding erosion; for being the shelter for other animals, birds, rodents and invertebrates; for being the source of food for human and other life forms; for being the wood need for building houses, furniture, or fire; for being the main source of our paper production in future industry; for being a source of medicine; and finally being the most important element of the backbone and balance of ecosystem locally and globally.

The importance of these forests that they have tree species growing under Jordan's local, specific, environmental condition **(Fig. 6.4)**.

One might say that is the same forest species grow in other neighboring countries or other parts of the world?. The answer is, yes, it is true, but still the plants growing in Jordan are growing under the specific environmental condition of this country, thus they are ecologically unique and have genetically fixed characters.

Fig. 6.4. Showing ***Tamarix arborea,*** a tree species occurring in Azraq Oasis area that can be used as wind breaking and fencing plant especially in saline and dry places, as well as a source of timber and wood.

Some of the forests in Jordan are well isolated in distribution from similar forests of the same species by hundreds or even thousands of kilometers, then they are of special gene makeup to be called genotypes. Example of that is the Juniper forest (***Juniperus phoenica***) in Southern Jordan where it is isolated ecosystem and occurs on special rocks of Kurnub sand stones which does not hold water as good as other soil types. Again we still have less than a hundred trees of wild ***Cupressus sempervirens,*** of more than One thousand years old. It is clear that such few isolated trees have a unique genetical makeup which are highly advantageous for the country natural resources.

In fact such ecological and genetical variations have been taken by taxonomists to describe new or to consider different species. Accordingly, **ZOHARY** (1966) treated the forest tree ***Quercus coccifera*** as a distinct species named ***Quercus calliprinos***. I do not agree taxonomically with this treatment of ***Quercus calliprinos*** as a distinct species since ***Q. coccifera*** has almost a continuous distribution in the Mediterranean basin.

The presence of different tree plants such as ***Pinus halepensis, Quercus coccifera, Q. ithaburensis, Pistacia palaestina, P. atlantica, Ceratonia siliqua, Pyrus syriaca, Crataegus spp., Cupressus sempervirens*** and others is very significant as the best species to be selected for our national programme of reforestation.

6.5.2. Food plants

Since the early days of human life activity the wild plants were the main and only source of food. Later on, man has developed new methods of breedings and cultivation of edible plants. Nevertheless, human beings have not stopped using plants from their wild origin until this moment. In fact there is a great interest growing on nowadays between modern civilisations to go back to nature and eat wild plants. So it is no surprise that the price of wild mushrooms or other edible plants are many times more than cultivated ones. Politically speaking the wild edible plants are considered as important source of food security for each country.

AL-EISAWI & TAKRURI (1989) have listed 142 wild edible plants used by locals in Jordan. It was proved that the concentration of some

vitamins and minerals is few times more than it is in other major sources of cultivated vegetables.

Some of the wild edible plants are the fruits or the seeds of trees such as: ***Ceratonia siliqua, Pinus halepensis, Ziziphus lotus, Z. spina-christi, Crataegus aronia*** etc.; fruits and seeds of some herbs such as: ***Tetragonolobus palaestinus, Pisum sativum, P. syriacum, Lathyrus cicera, L. gorgonei, Vicia narbonensis, V. hybrida*** etc.; or leaves and fleshy parts of herbs such as ***Malva nicaeensis, Rumex cyprius, R. pulcher, Origanum syriacum, Gundelia tournefortii, Foeniculum vulgare, Cichorium pumilum*** etc.

6.5.3. Parents of crops and cultivars

Most of our economic plants especially those used in modern agriculture are coming from the wild origin. Essential crops such as cereals, legumes, vegetables, oil, fibers, coffee, tea, spices etc., have come directly from wild origin or have passed through a long process of selection during the human history of agriculture and civilisation.

Until this moment of science advancement and biotechnology, such as tissue cultures, bioreactors, genetic engineerings, gene banks etc., the need for going back to the wild origin is emphasized.

Jordan as part of the Middle East and part of the old world is well known for its history of early civilisation, cultivation and natural richness of biodiversity. In fact the Middle East, Asia Minor and Central Asia are considered the centre of speciation in the old world (**HEYWOOD**, 1978).

Southern Syria, Northern Palestine and N. Jordan are the origin of cereal crops of wheat and barley. ***Triticum dicocciodes*** (wild wheat), five species of ***Hordeum*** (wild barley) ten species of ***Aegilops*** (parents of wheat) and six species of ***Avena*** (wild oat), all occur in Jordan.

Also lots of the cultivated legumes have wild origins in Jordan. Three species of ***Pisum*** (wild peas), three species of ***Lens*** (wild lentil), two species of ***Cicer*** (wild chickpea), 12 species of ***Vicia*** (vitch and broad beans), are wild legumes in Jordan.

All of the previously mentioned examples in addition to many others are important sources for plant breeders to produce new cultivars of specific characteristics. Therefore, these plants should be treated with great care as valuable genetical resources (**FLOWER & MOONEY**, 1990).

6.5.4. Ornamental Plants

Every body enjoys to see beautiful flowers, roses, Orchids, flowering bushes and shrubs in the living or working area. Home gardens, local gardens, common gardens, specialised or botanical gardens are full of flowers and special plants. Some of these plants were taken from the wild to cultivation as they are, some others have received special attention by plant breeders and plant horticulturalists.

In the past, every flower or showy plant was directly collected from the wild, but now one can go to a plant shop supplier and buy his needs in every season. One can buy corms, bulbs or rhizomes of ***Iris, Crocus, Colchicum, Tulipa, Lilium*** etc., or seeds of: ***Aster, Dianthus, Anttirhinum, Chrysanthemum, Alyssum*** etc. from the shop. Of course all of these came from the human use of his wild natural resource.

In Jordan there are lots of plants which can be used for ornamental purposes as follows:

i. Trees and shrubs: there are beautiful flowering trees and shrubs can be used as garden, street or road sides which are adapted to the local environment. These plants are going to succeed in cultivation, in fact the few examples so far used have proved so. Examples of such plants are: ***Ceratonia siliqua, Cercis siliquastrum, Styrax officinalis, Arbutus andrachne, Nerium oleander, Retama raetam*** etc.

ii. Bushes and perennial herbs: ***Cistus creticus, C. salvifolius, Astragalus spp., Salvia spp., Capparis spp., Argyrolobium crotalarioides, Ononis natrix*** etc.

iii. Bulbs, corms and rhizomes: in Jordan there is a wide range of most beautiful bulbous plants. In fact some of these are endemic. In Jordan there are 12 species of ***Iris*** 5 of them are endemic; 8 species of ***Crocus*** 2 of them are endemic; 8 species of ***Colchicum*** 2 endemic; 3 species of ***Tulip***; more than 20 species of ***Allium***; 24 species of ***Orchis***.

It can be said that the number is not so important, but the most peculiar about some of these mentioned plants that they grow under dry ecosystem, even some are confined to the desert. In addition to that the colour and size of these flowers are exceptional. Accordingly, the endemic species ***Iris nigricans*** has been selected as the national flower.

6.5.5. Medicinal plants

It is estimated that about 500 species of medicinal plants are recorded in Jordan. This number comprises 25% of the flora. Some of these plants have been tested by local people through generations. And thus the experience have been passed from generation to generation. Medicinal plants have extremely important roll in the future use and economy of the country.

6.5.6. Potential root stock

Appreciable research is concentrated nowadays to produce varieties and cultivars adapted to drought or disease resistant. Because of that the cultivation of some fruits and crops is restricted to a limited area where enough rainfall is available.

But if we have certain species grow in dry conditions and under low amount of rainfall especially less than 200 mm per year. And if such species can be propagated and used as root stocks, then the chance to cultivate fruit trees resistant to drought, low rainfall and resistant to diseases is very possible. Scientific research in this respect is going on now in cooperation between the faculty of agriculture and faculty of science at the University of Jordan, Amman.

Examples of wild species which can be used as root stocks are:

Amygdalus arabica, A. communis, A. korschinskyi, Cerasus microcarpa, Crataegus aronia, C. azarolus, Pyrus syriaca, Rosa canina, Olea europaea etc.

6.5.7. Sand dune fixatives

Lots of dry places in the world especially those with the majorityof deserts and sand dunes suffer a lot from the movement of sand, sand storms, and air pollution. At the same time lots of efforts and costs were paid to stop the shifting of such sands and to prevent dusty clouds which cause serious damage on properties and human health.

One of the best solutions for such harsh natural conditions is to find a natural durable solution. The best of those is to find plants able to grow under the desert dry conditions to fix and to prevent the sand movement. Such sand fixatives are very precious to have. Luckily, Jordan has some of these important plants as: ***Haloxylon persicum, Calligonum comosum, Hammada scopira, H. salicornica, Traganum nudatum, Panicum turgidum*** etc.

6.5.8. Range lands and conservation

The majority of Jordan land is dry, and only up to 10% of the total area can be used for cultivation without irrigation. Based on that 90% of the country receive only small amount of rainfall to support natural cultivation.

Due to that, Jordan is classified as a range land country. Despite of these facts there are plants in Jordan, growing in the desert and under a rainfall of only 50 mm per year (**Figs. 6.5 & 6.6**). It is amazing how such plants are adapted to such conditions. There are lots of legume plants especially those are able to fix nitrogen by having nodular bacteria are growing in the desert such as: ***Medicago spp., Astragalus spp., Vicia spp., Trigonella spp.*** etc.

In some studies on the natural reserves in the Eastern Desert it was proved that the ecosystem is very rich and highly diversified and able to start building up the series of desert climax, simply by fencing (**Figs. 6.7 & 6.8**).

Unfortunately, such critical dry ecosystems are under severe threat due to irrational human activities, especially land plowing for cultivation or ownership, overgrazing, cutting shrubs for fire production and

concentration of animal breeding to exceed many time the animal carrying capacity.

Finally, regardless of all of these negative aspects of having limited rainfall, yet Jordan is a very rich country in terms of its genetical resources. Therefore, sincere efforts are badly needed to protect such national heritage using all means of conservation, gene banks, seed banks, botanical gardens, national parks as well as modern biotechnological methods.

Fig. 6.5. Showing effect of overgrazing on the vegetation. Notice goat and sheep outside the fence.

Fig. 6.6. Showing effect of fencing in natural reserve protection. Notice vegetation outside and inside fence. (Daba'a Reserve, Irano-Turanian region).

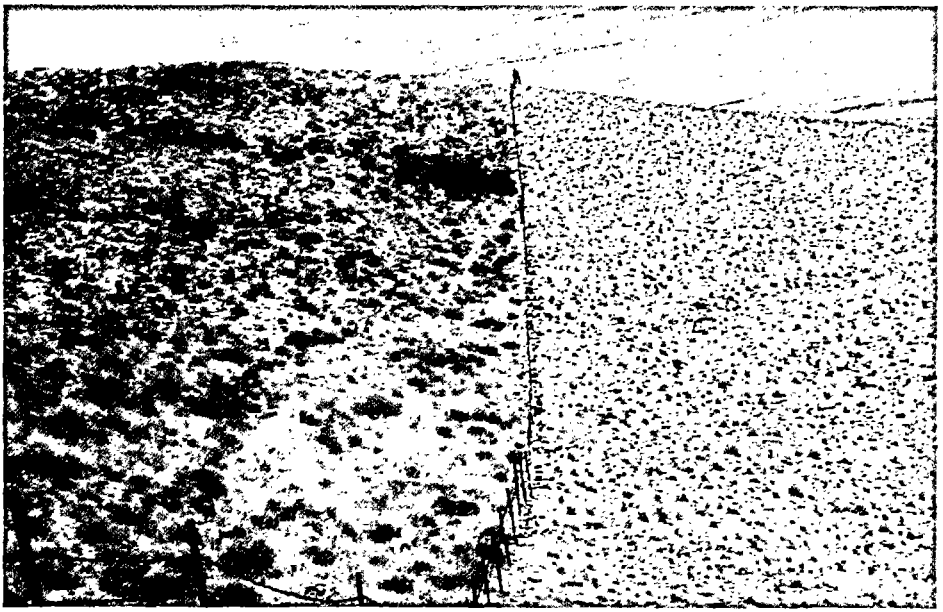


Fig. 6.7. Shaumari Reserve showing dense vegetation cover under natural condition within the protected area.

Fig. 6.8. Showing a bird nest as a result of conservation and reserve initiation. This indicates the ecosystem is reestablishing itself to normal situation.

7. FLORISTIC INFORMATION

7.1. Flora richness

7.2. Flora analysis

7.1. Flora Richness

Flora of Jordan is represented by the total number of plant species growing within the boundaries of the country. Such plant species can be classified as herbs, bushes, shrubs and trees. The herbs here means herbaceous (not woody plants) annual, perennials or bulbous plants. The bushes are short, perennial, woody, usually many stemmed rounded to hemispherical plants, their height does not exceed 50 cm. Shrubs are perennial, woody plants with many stems, their height ranges from 1-4 m. Trees are perennial woody plants with a single stem and their height is more than 5 meters.

In Jordan combination of these forms of plants occur in the different geographical regions as discussed previously. Some of the herbaceous plants are beautiful showy, others are thorny or spiny not showy, a third group are succulent or fleshy since they grow in dry hot area.

Although, the total area of Jordan is about 90,000 Km², yet it is considered very rich in terms of plant biodiversity. The total number of species is about 2400 -2500 species, this nuber was recoreded to be about 2200 (**AL-EISAWI**, 1982). This total number is almost one and a half time as much as the number of species growing in UK and Ireland together. Again they are more than the number of recorded floras of many European countries, that exceed many times the total area of Jordan.

One might ask why such a big number of species in such a small country?. The answer to that is: the occurrence of four biogeographical regions in a limited space has led to large number of species and speciation. One can recognize variations in a short distance. This huge ecological variation can not be observed in a place like Germany or UK.

In one hour trip one can visit four biogeographical regions. Let us cross the road from Zarka or from Muwaqqer through Amman down to the Dead Sea, or from Zarka to Amman down to Salt and Dair 'Alla. Within either of these trips one can pass through the desert (Saharo-Arabian), then steppe (Irano-Turanian), then the mountains (Mediterranean) and again steppe and finally to the Rift Valley (Sudanian or Tropical).

Such extreme variation is reflected in plant and animal species variations one can observe along these trips. Such variation has been used in many parts of the world as an important source of ecotourism.

Coming back to the total number of species. How can we split them into more useful categories?. To answer that question again, it is important to list the following facts:

i. The plants growing in Jordan are well adapted to the local conditions and have fixed their genetical structure during hundreds, but in fact thousands of years. Imagine how much it will cost in time, money, and human power to import such plants to grow under our harsh conditions. It is just reasonable to understand how much money, effort and time it took us to initiate the few man made forests in Jordan. I am sure you will be shocked if one says that within the past fifty years with the effort and good wills it was not possible to cover even 0.05% of the total area. In fact you will be shocked more to know that the total forest cover in Jordan (natural plus man made) is only about 0.08% of the total area.

ii. In Jordan 20% of the total flora is recorded as being used as medicinal plants comprising a total number of about 500 species (**ORAN & AL-EISAWI,** 1994). The amazing thing about these plants that they grow under the specific harsh, dry condition of Jordan. Such plants have been used for generations by the local people and still are successfully used by Bedouins and villagers. Few of these plants have been introduced to cultivation, but many have never been tried.

iii. Many wild plants in Jordan are considered the wild genomes (parents) of many present crop cultivars. The origin of cultivated wheat and barley and their wild parents are found in greater Syria including Jordan. The wild pea species are again found in the same area. Three species of wild pea ***Pisum*** grow naturally in Jordan. Eleven species of

wild beans and vetch ***Vicia*** are growing naturally in Jordan. The same can be said for fruit trees such as almond, pistachio, figs etc.

iv. Many wild ornamental species are growing in a wide range of habitats in Jordan. Some are typical mountain species, while others are growing in the desert or Wadi Araba. In most places of Europe the wild ***Iris*** is well known to grow at the lake shore, while in Jordan they grow in dry places often in very dry areas. The most beautiful Irises of Jordan are growing in desert areas. In fact there are five endemic species.

v. The forest trees growing in Jordan are well adapted to our condition and can grow at a low rainfall of about 300- 500 mm / year. In fact some trees have found to be growing in the heart of the Jordan desert. Some of these trees can be used for the national reforestation programme without having to import species and risk the chance of their failure of acclimatisation. Others are beautiful ornamental species that can be used as street trees or gardens.

All of the previously mentioned in addition to some more can really show the wealth of this country in its genetical resources.

7.2. Flora Analysis

The presence of unusual ecological conditions in Jordan has very much affected the plant life and the biological diversity in terms of species diversity, density and distribution. Based on these facts about 2078 species were recorded in Jordan (**AL-EISAWI,** 1982). Since then more than one hundred new species and new genera have been recorded (**AL-EISAWI,** 1986a, 1986b; **AL-EISAWI et al.,** 1994). There are still new more species which have been collected under publication. It is certain that still more new species will be discovered in the future, based on extensive surveys especially in remote and isolated areas. However it is expected that the total number of the flora will be around 2500 species.

The total number of vascular plant species in Jordan are belonging to about 730 genera and 122 families. Such numbers of species are considered to be a great wealth in terms of, national heritage and international use for man kind. This was confirmed by United Nation

Agencies such as **UNEP, FAO, IUCN, IPGRI, WRI, WWF, WHO, UNESCO** etc. Lots of publications related to the use and conservation of Biological Diversity have been produced (**DAVIS et al.,** 1986; **FLOWER & MOONEY,** 1990; **AKERLE et al.,** 1991; **GROOMBRIDE,** 1992; **UNEP,** 1992; **COURRIER,** 1992).

The importance of the flora of Jordan in terms of uses as genetical resources for local people and mankind has been extensively explained in the importance of biodiversity as a genetical source chapter **6.5.**

7.2.1. Elements of the flora

Jordan is classified to contain four biogeographical regions as a result of the physical aspects prevailing in this little country. Accordingly very odd and variable conditions are present in different parts of Jordan. For example one can cross the four geographical region fro East to West in about one hour time. If the journey starts from the desert castles of Qasr Amra and Qasr Al-Harranah (Saharo Arabian region) and passes through Muwagger and Sahhab (Irano-Turanian region) then to the mountains of Amman(Mediterranean region) and descending towards the Dead Sea through the hills between Na'our and Suwwaimah (Irano-Turanian) and finally reaching the Rift Valley and the Dead Sea (Tropical, or Sudanian region). This trip is easy enough and highly exciting for the biologist and none biologist due to the sudden change in biomes in a very short period.

The components of the flora of Jordan in relation to their affinities are subdivided into four groups:

1. Mediterranean elements.
2. Irano-Turanean elements.
3. Saharan elements.
4. Tropical (Sudanian) elements.

7.2.1.1. Mediterranean elements

This group of plant species comprise the majority of the flora elements. The arboreal species are the most impotent members through which a forest formation was dominant in the mountain highlands of Jordan. Examples of these elements are: ***Quercus coccifera, Q. ithaburensis, Pinus halepensis, Juniperus phoenica, Cupressus sempervirens,***

Ceratonia siliqua, Pistacia palaestina, Cercis siliquastrum, Arbutus andrachne, Calycotome villosa, Rhamnus palaestinus, Cistus salvifolius, C. creticus, Sarcopoterium spinosum, Anagyris foetida, Acanthus syriacus, Anemone coronaria, Ranunculus asiaticus, Anchusa strigosa, Alkanna tinctoria, Ononis natrix, Narcissus tazetta, Orchis anatolica, Ophrys sphegodes O. fusca, Dactylis glomerata, Tulipa agenensis, Origanum syriacum, Ornithogalum narbonense.

7.2.1.2. Irano-Turanian elements

It is an area that surrounds the Mediterranean region from all sides except in the North. Accordingly many plant species of both Mediterranean and Irano-Turanian can intermix in their distribution, but still there are typical Irano-Turanian elements such as: *Anabasis syriaca, Noaea mucronata, Salsola vermiculata, S. inermis, Hammada eigii, Achillea santolina, A. fragrantissima, Varthemia iphionoides, Gypsophila arabica, Matthiola aspera, Erucaria pinnata, Diplotaxis erucoides, Torularia torulosa, Sisymbrium runcinatum, Texiera glastifolia, Cardaria draba, Adonis dentata, Artemisia herba-alba, Salvia lanigera, Pimpinella eriocarpa, Poa bulbosa, Crocus moabiticus, Tulipa polychroma, Ephedra alte, Capparis parviflora, Boissiera squarrosa, Crithopsis delileana, Lactuca orientalis.*

7.2.1.3. Saharan elements

The eastern desert is the largest area in Jordan and covering a range of soil and climatic variation. There are lost of species well adapted to the conditions of this area that can be considered typical desert elements. The followings are some of the representing elements: *Diplotaxis harra, Zilla spinosa, Seidlitzia rosmarinus, Halogeton alopecuroides, Halothamnus acutifolius, Suaeda vermiculata, Colchicum tunicatum, Rheum palaestinum, Astragalus spinosus, Scorzonera syriaca, S. schweinfurthii, Lepidium aucheri, Savignya parviflora, Atriplex leucoclada, Reichardia tingitana, Asteriscus pygmaeus, Atractylis phaeolepis, Gymnarrhena micrantha, Leontodon laciniatus Filago desertorum, Iris postii, I. aucheri, Gynandriris sisyrinchium. Schismus arabicus, Eremopyrum bonaepartis, E. distans, Rhizocephalus orientalis, Eremostachys transjordanica, Alcea chrysantha, Verbascum transjordannicum.*

7.2.1.4. Tropical (Sudanian) elements

These elements are restricted to the Rift Valley area, especially Dead Sea, Wadi Araba, and Wadi Rum. The most important elements are: ***Ziziphus spina-christi, Maerua crassifolia, Balanites aegyptiaca, Calotropis procera, Salvadora persica, Ochradenus baccatus, Acacia tortilis, A. raddiana, Cassia italica, Reseda muricata, R. arabica, Aerva javanica, Aizoon hispanica, Opophytum forskahlii, Capparis decidua, Periploca aphylla, Leptadenia pyrotechnica, Abutilon fruticosum, Cocculus pendulus, Commicarpus plumbagineus, Ficus pseudo-sycamorus.***

7.2.2. Flora composition

The families comprising the flora of Jordan are 122 and 730 genera. The largest families and most dominant in terms of genera and species numbers are arranged descending as follows: **Compositae, Gramineae, Leguminosae, Umbelliferae, Cruciferae, Labiatae, Caryophyllaceae, Liliaceae, Boraginaceae, Chenopodiaceae**. While the largest genera are: ***Astragalus, Trifolium, Silene, Euphorbia, Allium, Galium, Centaurea, Medicago, Anthemis, Salvia, Vicia, Trigonella, Ranunculus, Plantago, Erodium.***

8. MAN INFLUENCE ON THE NATURAL PLANT COVER

8.1. Mountains

8.2. Jordan Valley

8.3. Dead Sea

8.4. Wadi Araba

8.5. Marginal Land, (Steppe)

8.6. Eastern Desert

8.1. Mountains

8.1.1. Mountain vegetation in Jordan

In Jordan the mountain vegetation is dominated by forest types or degraded forest land. In general the land of the mountains in most cases is fertile and receives the highest amount of rainfall. Five vegetation types are recognized in Jordan (**AL-EISAWI,** 1985) and these are:

A. Pine forest
B. Evergreen oak forest
C. Deciduous oak forest
D. Juniper forest
E. Non-forest vegetation

In this mountainous region Mediterranean flora elements are dominant especially the tree species such as: ***Pinus halepensis, Quercus coccifera, Q. ithaburensis, Juniperus phoenica, Pistacia palaestina, P. atlantica, Ceratonia siliqua, Arbutus andrachne, Crataegus aronia, C. azarolus, Amygdalus communis*** and ***Cercis siliquastrum.***

In addition to that lots of shrubs and annual herbs occur under the forest formation. The most important and most endangered species are the Orchid species such as: ***Limodorum abortivum, Cephalanthera longifolia, Orchis anatolica, O. papilionacea, Ophrys apifera, O. fusca, O. transhyrcana, O. galilaea*** and ***O. carmeli.***

8.1.2. Causes of mountains vegetation and forest destruction in Jordan

Mountains vegetation and forest have been destroyed through different human activities that can be linked to the following:

8.1.2.1. Destruction for buildings and rural development

Most of the large cities in Jordan are located in the mountain region. These cities have almost more than 90% of the population. Therefore, the spread of these cities was at the expense of the fertile and forest land.

It is justified to say that the population in Jordan has more than doubled since 1950. In fact it was only 400 thousand in 1947 and now it is about 4.1 million (See Table 1, taken from Jordan, **NATIONAL STRATEGY,** 1991). This means that the population has increased 10 times since 1950. The reason for this is the rate of population is one of the highest in the world, almost 3.5%. In addition a small country like Jordan has received three waves of Palestinian immigration in 1948, 1967, 1990. And these are based on the occupation of Palestine in 1948, the Arab Israeli war in 1967 and the Gulf war 1990. These waves of immigration have caused immense pressure on Jordan's Natural Resources and have affected wildlife and forest area negatively. The following table shows the population increase during this century (Taken from the **NATIONAL STRATEGY FOR THE PROTECTION OF THE ENVIRONMENT IN JORDAN,** 1991).

YEAR	POPULATION	GROWTH RATIO
1922	225,000	
1938	300,000	1.8%
1947	400,000	3.2%
1952	586,000	7.8%
1961	901,000	4.9%
1979	2,122,000	4.9%
1993	4,152,000	3.8% (Latest account)

It is enough to say that all of these human waves came to the well established cities or near by. Imagine that the capital city Amman was much less than 100 thousand in 1950 while, it is now about 1.7 millions. In fact Amman and the near by cities, Salt and Zarka are connected. The total number of the population in these cities is about 70% of the whole population. It is obvious that all the forests near by have been largely cleared.

The worst thing about the spread of cities and rural development is the problem of unorganized building of cities and towns according to well studied plans. Recently and within the boundaries of the major cities there are fairly good plans. But the suburbs of these cities were and still are badly or even not at all planned to fit any scheme. The accumulation effect of the old suburb areas has affected the outline plans of the cities since these old suburbs are now well connected to the cities.

This spread of cities in such organized way has totally destroyed the forest vegetation around them.

8.1.2.2. Destruction for farming

The increase in population is automatically associated with increase in food demands. It is also natural to say that a population increased more than four folds in the past forty years will be definitely followed by more than four times food needs. Certainly this huge food demand will be reflected on the destruction of the forest for establishing new farms.

This was absolutely true in Jordan because the fertile land is restricted in the mountainous region which does not exceed at its best 10% of the total land in the country. This same area was one time the forest cover in Jordan.

In fact one can observe the decline of the limited forest area every day since there is a great demand on food products.

One of the problems in this respect is that parts of the natural forests in Jordan belong to private owners, which reduces the influence of the government to interfere. In fact there is a project called high land development which is good in some respects that it encourages people to make stone terraces to protect soil erosion and to enhance land for cultivation. Unfortunately, this project has gave forest owners a legal cover to clear forest. This high land development opponent project should be restricted to the waste high lands only (**Figs. 8.1 & 8.2**).

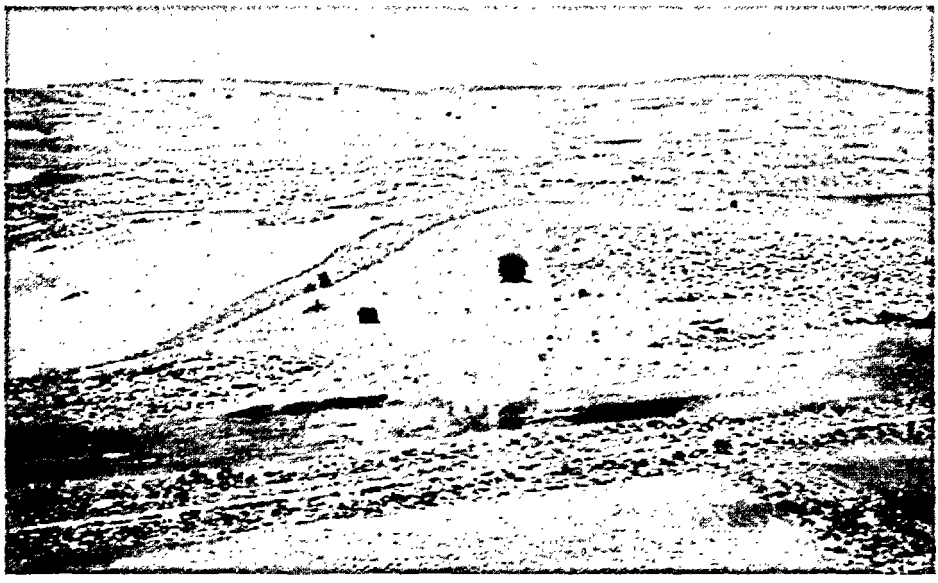
Although, Jordan is classified as an agricultural country but we still import more than 50% of our food. It is deceiving to know that we are exporting fresh vegetables such as Tomato, Egg plant, Pepper and few other things, but still we import the majority of our needs such as wheat, dairy products, meat, rice, sugar and much more than that.

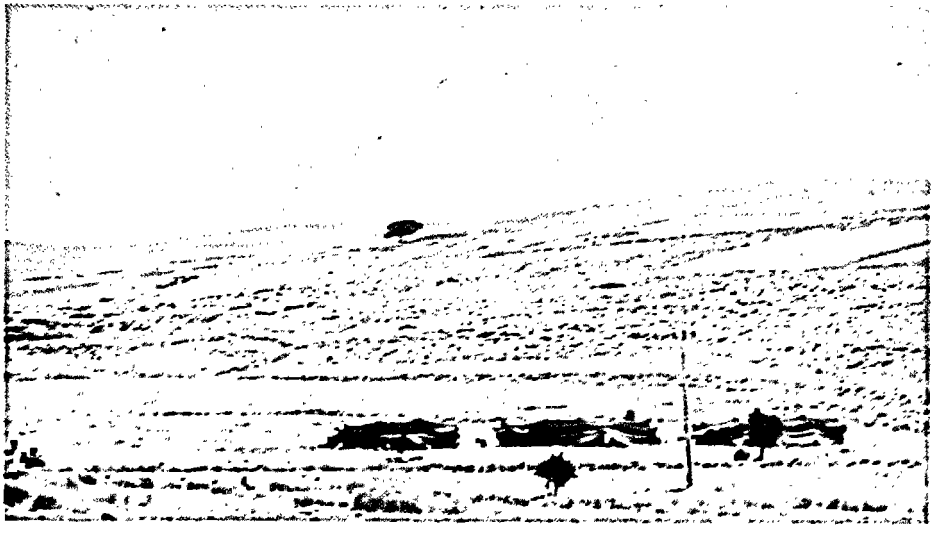
8.1.2.3. Quarries for stone and building material

In Jordan most houses are built using natural limestone after being nicely cut and shaped. In addition lots of the concrete material also are coming from limestone.

Fig. 8.1. Showing forest destruction through land use for cultivation. Notice stone terraces for farm formation.

Fig. 8.2. Forest destruction by man impact. The photograph is showing a single oak tree (*Quercus coccifera)* as a remnant of oak forest in Jibal Ash-Sharah, South Jordan (upper). Notice Bedouin tents in the fore front of the picture (lower).





The best material of stones and building material comes from the hard limestone. Unfortunately, the hard limestone is the parental material for the most fertile red soil (Terra Rossa) where the oak forest grow in Jordan and other Mediterranean countries. This demand in fact caused the destruction of good amount of forest land due to the high price of the stone material **(Fig. 8.3)**.

8.1.2.4. Roads and industrial areas

Civilizations is often preceded and followed by infrastructures. The basic units of these are roads and communication systems. In the past major cities were connected with narrow roads and villages by foot tracks or animal tracks. Nowadays cities are connected by highways and villages became towns and thus connected by wide roads. Before 1950 it was very curious in Jordan to see a car, nowadays cars are the most common and destructive pollutants. This is true in other places in the world, but when we talk about all of the previous causes of destruction in a limited area, then we can assume the amplitude of the problem **(Fig. 8.4)**.

8.1.2.5. Grazing

Although, there are rules to forbid grazing in the forest land, but still there are lots of violations in different parts The most harmful effect on vegetation is the destruction of herb vegetation elements as well as the new seedlings of the trees and shrubs association. This grazing effect is more serious in Jordan since most of the grazing animals are goats. On the long run the grazing effect will cause soil erosion, loss of rare elements and the most important is the halt of regeneration of the forest. Thus no forest replacement occurs, but on the contrary, the decrease in density, destruction and soil erosion.

The problem of grazing in Jordan is highly illustrated in the Southern part of Jordan in Ash-Sharah Mountains with a little less in AL-Alouk and Northern Jordan. The shape of tree becomes very odd sometimes since it tries to protect itself by producing new shoots, Therefore, it becomes rounded in shape and the trunk can not be seen **(Figs. 8.5 & 8.6)**.

Fig. 8.3. Showing the effect of forest and land destruction by quarries.

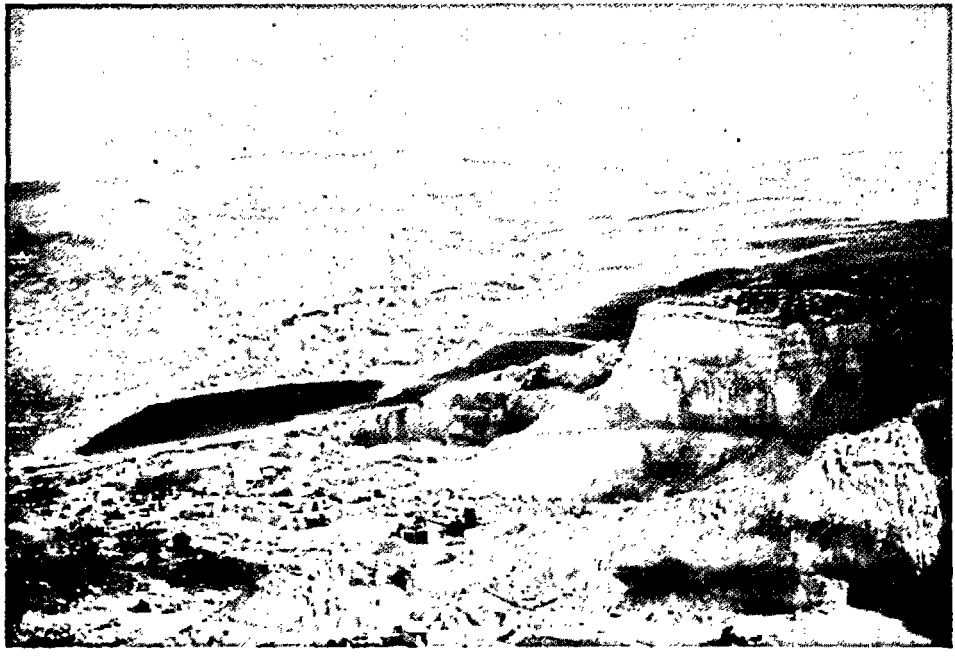


Fig. 8.4. Showing plant distribution along the road sides due to seed transport and dispersal by vehicles, Wadi Araba.

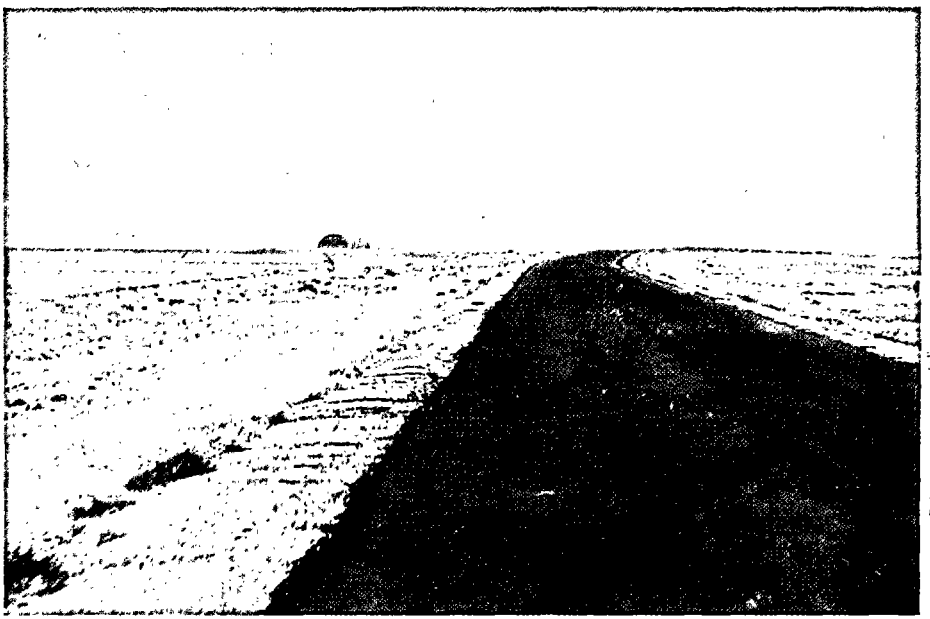


Fig. 8.5. Showing heavy grazing and the effect of that on the vegetation especially the disappearance of annual and palatable plants.

Fig. 8.6. Showing oak tree (***Quercus coccifera***) taking a round shape especially at the base as a protection from grazing effect. Notice that the stem is hidden due to proliferation of young shoots.

8.1.2.6. Coal production

The use of coal in Jordan is quite limited, it is mostly used for Bar-B-Q or very limited for water pipes (the Turkish style). Other than that the destruction of forest for this purpose in recent time is more or less neglected.

The major hits for the use of forest for fire and coal can be referred to two periods:

a. During the end of the nineteenth century and the beginning of this century especially during the first world war a steam train line was connecting Turkey to Madena in Saudi Arabia, known as Hijaz railway line.

Jordan forests were the main source of fire supply for that line, since almost no forests are available in the Hauran (South East Syria) or in the Eastern Desert in Jordan and all along the desert line to Saudi Arabia. In fact this has caused the destruction of thousands of hectares of forest cover in Southern Jordan. Only forest remnants such as a single wild tree or just few shrubs of the forest ecosystems can be used as indicators (**Fig. 8.7**).

b. Destruction of forest for house heat and baking bread during the beginning of this century until almost mid sixties when petrol products started to be more available and more popular. This problem was very much enhanced by the waves of Palestinian refugees to Jordan in 1948 and reached its peak around 1955.

8.1.2.7. Fire

Usually it is very rare to have fire in natural oak forest, but contrary to that it is common to have fire in pine forests especially man made (**Fig. 8.8**). The reason for that is that the density of pine trees is much more than its natural occurrence. In addition, pine trees are very rich in resin which enhances the fire start and continuation. Therefore, oak forests are more resistant to fire than pine forest.

It is known that oak trees are able to regenerate if the above ground parts are subjected to cut or burning (**Fig. 8.7**). Opposite to that pine

trees can not generate if they are subjected to cut or burning. Therefore, oak forests are more suitable to resist such hazardous effect.

In General fire causes in Jordan can be referred to:

a. Mostly through human carelessness during dry summer time as a result of throwing cigarettes to the road side.

b. Or over the week ends during picnic time as a result of starting fire for Bar-B-Q in the forest or leaving fire carelessly after using the place.

Fig. 8.7. Showing human destruction of forest. Notice remnant of an oak tree (***Quercus coccifera***).

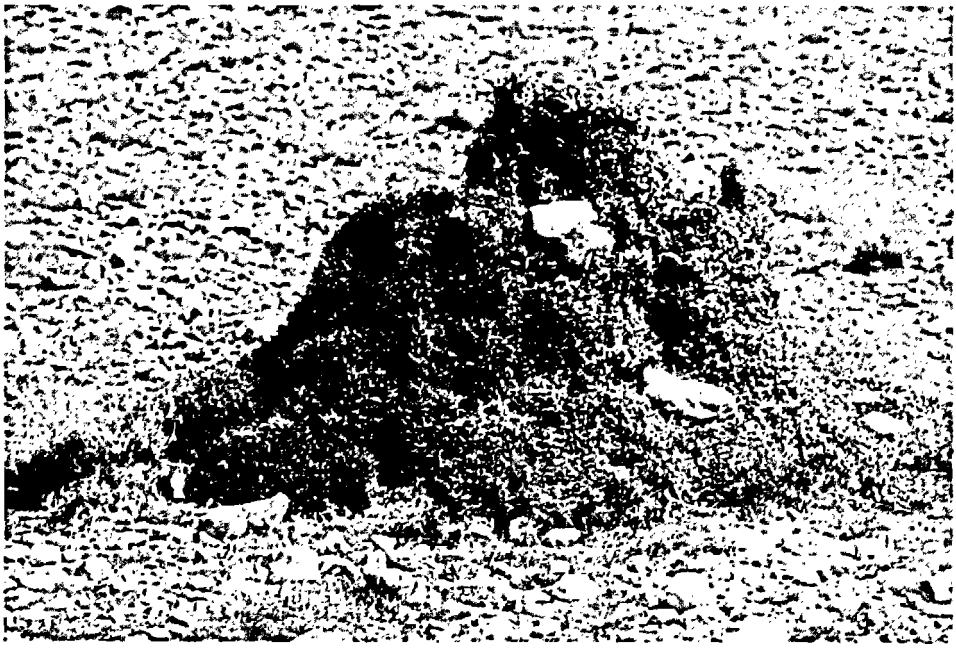


Fig. 8.8. Showing fire effect on forest. Notice burned Pine forest, ***Pinus halepensis***.

8.2. Jordan Valley

The Jordan Valley extends from Lake Tibierias in the North to the Dead Sea in the South, where the final outlet of the river. Most of the water was transferred by a diversion canal by Israel in 1964 to the desert of Naqab (Negev).

The Jordan valley or what is known locally as Ghor AL-Ordon is subdivided into three region in Jordan as:

i. Northern Ghor
ii. Middle Ghor
iii. Southern Ghor

8.2.1. Northern Ghor

The Northern ghor is restricted to the areas north of Dair 'Alla, especially Shuneh Shamalieah (Northern Shuneh), AL-Mashare', Ghor AL-Yabis. This area is characterized by having higher altitude, better rainfall, less saline soil and fertile land with lots of alluvial red soil. The area is heavily cultivated mostly by Citrus orchards, Banana orchards and vegetables.

At the Northern side of this area one can observe the deciduous oak forest at the high mountains. One single species unique to the Northern ghor is ***Ziziphus nummularia.*** This species starts to mix with the deciduous oak forest at the ridge of the mountains from West of Ajloun to Um-Qeis, in the North and increases in distribution towards the Western slopes until it reaches the Jordan Valley. This species does not occur any where in the Jordan Valley except there.

This part of the Jordan valley is cooler than other two regions where tropical vegetation will be almost not present as it is in the other two regions. In cold seasons a touch of frost sometimes reach and affect this part, causing a great loss in vegetable crops. Most of this area is used for cultivation except of some hilly parts at the Southern end, where Lissan Marls are confined and characterised by high salinity with special vegetation of ***Atriplex halimus, Lycium depressum, L. europaeum, Juncus maritimus*** and ***Suaeda spp.***

8.2.2. Middle Ghor

The middle part is warmer than the Northern part and of lower altitude. The soil is mostly alluvial with some sand proportion more than that of the Northern region. The soil in some parts has grayish to blackish colour. The soil is fertile and heavily used for vegetable cultivation. This part is considered as the main vegetable producing part in the whole Jordan Valley especially during the winter time.

The natural vegetation in this area was dominated by tropical vegetation especially ***Ziziphus lotus, Z. spina-christi, Balanites aegyptiaca*** and ***Calotropis procera***. The majority of the natural vegetation has been destroyed.

8.2.3. Southern Ghor

The Southern part of the Jordan Valley has a lower altitude, less rainfall and alluvial soil with a tendency to be more salty than the other two parts especially in the area close to Ghor Suwiemah. The soil in some places is gravely due to alluvial mixture brought from the eastern mountains.

The natural vegetation is composed of tropical vegetation more prominent than the previous two parts with thick stands of ***Ziziphus lotus, Balanites aegyptiaca, Calotropis procera*** and scattered trees of ***Ziziphus spina-christi***. Whenever soil becomes more saline especially close to river borders pure stands of ***Nitraria retusa*** are occurring forming almost a silt dunes in association with other salt resistant herbs especially ***Suaeda aegyptiaca, Psylliostachys spicata, Limonium lobatum***, etc.

The whole area has suffered from the followings:

1. Destruction of the natural vegetation due to the use of land for cultivation.
2. Invasion of weeds on the expense of wild species.
3. Changing the physical properties of the soil especially texture due to the continuous plowing.
4. Extensive use of the fertilizer has changed the micro flora and changed the species dominancy.

5. Extensive use of pesticide has polluted the soil and thus lots of the soil microorganisms as well as invertebrates have either disappeared or changed.
6. The ecosystem balance due to the previously mentioned reasons has been altered.
7. Lots of plant species, insects, birds and animals associated with the vegetation have disappeared.
8. Finally, the building of a new road parallel to the River Jordan known as AL-Ardani will definitely affect many species and will add to the problem of pollution resulted from the roads net work already existed.

8.3. Dead Sea

The Dead Sea has a unique environmental conditions that do not occur anywhere else in the world. It represents the lowest spot on earth (-400 m), characterized by having dry, hot condition and saline soil. Due to that it is a unique water body in not having living organisms, such as fish or algae. It is recorded that some types of halophytic bacteria were isolated from the water. However the high concentration of salts in that water does not allow real biological life especially during the past 30 years due to the diversion of the water of the river Jordan.

The Dead Sea is surrounded from both sides East and West by a system of Wadis which recharge their fresh water especially during the winter season, in addition to the River Jordan. This water flow used to keep the water level more or less balanced. but since lots of the water is used from these Wadis in addition to the diversion of the River Jordan the water level has gone down about 16 m. (Sea level is -416 m).

8.3.1. Vegetation

The natural vegetation around the sea was very rich and diversified especially at the Northern and Southern corners. The vegetation can be subdivided into the followings:

8.3.1.1. Saline vegetation

This type is mostly constricted in the Northern and Southern end of the Dead Sea. It is composed of dense structure of succulent, high salt.

tolerant plants. The vegetation usually starts 50- 100 m. away from the sea shore with the highest salt tolerant species close to the water dominated by: ***Arthrocnemum fruticosum, A. macrostachyum, Suaeda vermiculata, S. aegyptiaca, Mesembryanthemum nodiflorum, Juncus maritimus*** and ***Tamarix spp.***

Away from the water a different group of plants start to appear less tolerant to the salt such as ***Sonchus maritimus, Aaronsohnia factorovskyi, Rumex cyprius, Anabasis setifera, Inula crithmoides, Limonium lobatum, Nitraria retusa, Ziziphus lotus, Z. spina-christi, Acacia tortilis, Calotropis procera.***

At the Southern end of the Dead Sea especially close to Ghor Safi and Just before the Arab Potash Company a thick vegetation is present dominated by the same saline elements as well as tropical elements. The same tree and shrubby formation of the Northern side are present in addition to some important elements especially: ***Maerua crassifolia, Salvadora persica, Abutilon sp.*** and ***Cucumis prophetarum.***

8.3.1.2. Hot springs and water vegetation

Along the Eastern side of the Dead Sea specially at about a middle location there is a group of hot water springs running down to the Dead Sea. The water gets cooler as far as it is away from the origin. The whole group of hot spring is known as Zara, this in addition to the largest amount coming from the main hot spring and water fall of Ma'een.

Such type of fresh hot water has formed special types of tropical vegetation with certain species grow closer to the water such as: ***Phoenix dactylifera, Imperata cylindrica*** which forms dense patches of grass land, often mixed with ***Phragmites australis*** and the endangered orchid species ***Epipactis veratrifolia*** and ***Juncus spp., Inula crithmoides, Sonchus maritimus*** **(Fig. 8.9 & 8.10)**.

Few meters away from the water a wood land of dense vegetation is formed made of some trees and shrubs of: ***Ziziphus spina-christi, Moringa peregrina, Phoenix dactylifera, Acacia raddiana, A. tortilis, Calotropis procera, Tamarix sp., Ochradenus baccatus.*** and a rare plant and almost confined to that particular locality is the ***Capparis decidua.*** In addition there are some flowering parasitic plants such as

Loranthus acacia and climbers such as *Pentatropis spiralis* and *Cynanchum acutum.*

In places with fresh cold water other group of plants will appear led by *Arundo donax, Phragmites australis, Salix babylonica, Populus euphratica, Nerium oleander*. In the rocky, wet and shady places the maiden-hair fern *Adiantum capillus-veneris* was observed.

8.3.1.3. Rocky vegetation

At the hills surrounding the dead sea conditions are dry and the soil is highly poor and degraded, due to erosion and grazing.

The dominant species are mostly bushy types such as *Zygophyllum dumosum, Anabasis articulata, Astragalus spinosus, Noaea mucronata, Urginea maritima*. In the shallow wadi systems and run-off places small shrubs of the rare plant *Rhus tripartita* will be observed in addition to *Capparis cartilaginea* and *Ochradenus baccatus.*

8.3.2. Causes of vegetation destruction

8.3.2.1. Agriculture

The area around the Dead Sea is highly saline. Therefore, the agriculture was limited in some places near Suwaimah, Ghor Ath-Thira', Ghor Safi and Zara. The effect of agriculture is the same as previously mentioned for the Jordan Valley. Therefore, the destruction of the natural vegetation, replacement of naturally adapted species by invaders, replacement of woody vegetation by a herbaceous weedy vegetation in addition to the use of fertilizers and pesticides are encountered.

The most prominent effect is that related to burning the habitats of some rare and endangered naturally occurring species in the Zara area. The grass vegetation as well as the woody vegetation in the Zara area has been burned to be replaced by cheap quality farming system for growing Tomato or Aubergine (Egg plants) which are the least precious and the most common in Jordan. This behaviour has almost destroyed the restricted distribution of *Epipactis veratrifolia, Capparis decidua, Pentatropis spiralis* and *Cynanchum acutum.*

In Ghor Safi and Ghor Faifa vast areas of the halophytic vegetation have been destroyed for agriculture uses and thus lots of natural plant species have disappeared and replaced by notorious weeds.

8.3.2.2. Tourism

The Dead Sea area has always been the attraction of local people and visitors due to its pleasant climate during winter and due to the water characteristics which is believed that they have curing effect for many diseases especially skin diseases.

Lots of people through an unorganized tourism lacking the basic facilities in most places have led to irrational behavior of people as follows:

i. Parking the cars anywhere which have led to the destruction of the natural vegetation.

ii. Burning and breaking the vegetation especially when making fire for Bar-B-Q. or just to set late and have fun.

iii. Initiation of hotels and rest places has led and will in the future destroy and enhance the destruction of the natural vegetation based on replacement of sites and human activity.

iv. Accumulation of rubbish anywhere and everywhere has the most scenery depressing effect.

8.3.2.3. Road construction

Construction of old an the new Dead Sea road will have a serious effect on the destruction of the natural vegetation through human activity and pollution from vehicles. Already people have started to visit places which have not been reached before. Pollution, plastic bags, rubbish, and fire places can be observed all over the places

Unless such place are provided with proper tourism facilities and restriction of movement, the whole area will be very soon destroyed in no time.

8.3.2.4. Potash Company

The Arab Potash Company was initiated at the Southern end of the Dead Sea. It has replaced a rich area in saline halophytic vegetation. Huge area of the sea has been used as evaporation lakes. The trucks carry their potash loads and take them to the Gulf of Aqaba for export or for the fertilizer company to make super phosphate industry.

During loading splash of potash will be stuck at the body of the trucks that will be accumulated at the road side after leaving the company. The reason for this assumption is that the accumulation of potash along the road decreases after few miles from the factory, that means the trucks are well sealed.

The effect of potash accumulation along the road on the distribution of the plants or its effect on the balance of plant species dominance, or the plant-animal relation has never been studied or assessed.

If one travels along the road to Aqaba from Ghor Safi he will recognize this white salt-like powder along the road sides.

On top of that the factory has lots of vehicles that use diesel as the main source of power and need lots of grease and oil for lubrication, all of these will add to the pollution effect on the plant ecosystem and the biological diversity as a whole.

As a result of the factory initiation the population has increased in the area as a whole due to the initiation of a small town for the worker of the factory and as result of the enormous population increase in Ghor Safi village became as a medium size town. Therefore, we have always to consider sustainable development in our future plants by which we can make use of our natural resources but at the same time we have to maintain a balance of protection for our environment.

8.3.2.5. Grazing

Over grazing effect is becoming less prominent than it has been during the past 50 years. The Jordan valley people are more oriented to the cultivation processes rather than animal breeding unlike nomadic people of the Desert or Wadi Araba. In the past the grazing effect was much

more serious. Never the less, there is still grazing effect especially be goats or other animals. One can recognize this effect on various plants, for example ***Salvadora persica*** called Aaraak in Arabic is very rare and endangered species in Jordan, is a tree species (**Fig. 8.11**).

But due to the grazing effect this plant is only growing as prostrate shrubby like plant with many stems spreading over the ground (**Fig. 8.12**).

Fig. 8.9. Showing hot spring and water vegetation in Dead Sea area: grass land

Fig. 8.10. Showing the endangered species of rare Orchid ***Epipactis veratrifolia*** growing within the grass land vegetation around hot water springs in Zara area, Dead Sea.

Fig. 8.11. Showing a tree of ***Salvadora persica*** in normal vertical growth habit.

Fig. 8.12. Showing part of a tropical vegetation. Notice how a tree of ***Salvadora persica*** is spreading on the ground due to the grazing effect.

8.4. Wadi Araba

The vegetation of Wadi Araba was discussed as previously mentioned. In comparison to other parts of Jordan Wadi Araba can be considered as the least disturbed naturally. The reason for the conclusion is that Wadi Araba is considered remote, dry, very hot and the least populated. Therefore, effects of heavy population, pollution and human impact were the least relatively speaking.

Man impact on Wadi Araba can be accounted as follows:

8.4.1. Grazing

Wadis Araba has always been populated by nomadic people moving from one place to another with their herds of goats and camels. In some places the grazing was severe to be classified as heavy grazing. In my opinion the grazing in Wadi Araba has not affected the plant in term of number and occurrence as a biodiversity entity. It might affect the height due to browsing or the growth habit, but it won't forbid plants from growing and shedding seeds at the end of the season.

The species dominancy and distribution might be affected as a result of grazing by only one type of animals in the region ,the goats, due to their selection of preferable species for browsing. This habit through a long period of time it might affect the distribution and dissemination of certain species. This should not be taken as a pure fact since it is not supported by research dedicated for this purpose. Because it might be the reverse due to the continuous browsing plant species could developed a more advanced method to spread more effectively as a result of continuous pressure of threat.

8.4.2. Fire

As previously mentioned most of the inhabitants Wadi Araba are nomadic people who move from one place to another with their belongings and herds and settle in different places. Usually the only source of energy for cooking and making tea and continuous hot coffee is fir produced from plants. As a result if one can visit a Bedouin tent he should observe a bile of bushed always ready for backing bread or other home needs.

The habit has affected some rare species and even common species if the families stay for a long period of time.

8.4.3. Agriculture

Agriculture is quite limited at the time being in Wadi Araba, but in the near future there are plans to spread enormously and in vast areas. this of course will destroy the natural vegetation and biodiversity. It will lead also to the spread of notorious weeds, and finally pollution of pesticides, excessive use of fertilizers and plastic remnants.

8.4.4. Future plans

It is assumed after the peace process between Jordan and Israel that their will be lots of plans to invest the area in terms of: development, agriculture, energy, transport, etc.

It is also suggested to connect the Dead Sea to the Red Sea by a canal or to connect the Dead Sea to the Mediterranean by canal. In one lot the ecological consequences should be studied and considered very carefully.

8.5. Marginal Land (Steppe)

The marginal land in Jordan is characterized by having a rainfall ranges from 150-250 mm per year which fluctuates enormously from year to year that leads in some years to think that this area is highly fertile and receives a great amount of rainfall giving a deceiving assumption that this area can support a rainfed agriculture.

The soil also is mostly calcareous or loess with sometimes very shallow soil profile and in some other cases with very deep profile. Nevertheless, this soil can be highly productive if the water and irrigation system can be provided. But under natural conditions it can only support low shrub vegetation with no tree formation.

The climate of this region is rather intermediate between the Mediterranean and the deserts conditions, but it has never been a major

obstacle to prevent natural vegetation growing at its best under the prevailing rainfall and other conditions.

In general the marginal lands in Jordan are excellent places for grazing and can be considered as natural range lands. From our experience on reserves initiating in this habitat, it was proved that very rich and highly diversified vegetation occurs under natural conditions. Therefore, the best use of this land is to be used as natural range land and should not be used for rainfed cultivations.

The ecological affects on the vegetation and human impact can be counted as follows:

8.5.1. Agriculture

Vast areas of the marginal land have been ploughed during the past thirty years. This phenomenon has increased recently due to the availability of mechanical machines to plough the land through which one can achieve twenty times as much as traditional methods or more. Great areas are ploughed yearly for the cultivation of either Wheat or Barley. This was good enough in the past about twenty years ago, when a small group of Bedouins use to get few sacs of cereals for there yearly consumption. Nowadays the only purpose for this activity is to produce green fodder or a dry crop for the grazing of animals, since the cost of harvesting will be much more than the final income out of this cultivation.

Based on this irrational activities, most of the primary vegetation in the marginal lands has been destroyed and replaced by a secondary vegetation elements such as ***Anabasis syriaca*** **(Fig. 4.17)** which is a toxic plant and not palatable to animals. Worst than that, is that this species is acting as a fantastic host for rodents especially the Gerbil group, where they dig their burrows beneath these plants and they feed on them. The spread of such plants and accordingly the Gerbils in vast areas of the eastern borders of the Mediterranean region have led to the spread of the disease known as Leishmania.

It is known that this disease can be transported to human by a fly called sand fly, the same fly causes the same disease for the rodents as a secondary host. It is obvious that the destruction of the primary vegetation and the replacement by a strange weed have made a serious imbalance in

the ecosystem, through which an unexpected disease has spread in Jordan in no time.

The most serious effect of haphazard land ploughing is the destruction of the primary vegetation and making the soil particles loose, that will be finally shifted by winds leavened a barren land and thus causing desertification. This is one of the most serious problems of desertification in Jordan.

In other parts of the steppe land irrigated cultivation has taken place based on pumping underground water through drilling wells. Such agriculture activity has also destroyed the primary vegetation and caused the spread of obnoxious weeds that are not of local origin in most cases. The whole business of cultivation has changed species dominancy and species diversity in this part of the country.

8.5.2. Ownership

Most of the land in the eastern desert is classified as governmental land which means that it is owned by the government. But due to the trouble system common in Eastern Jordan, it has been recognized through time that there are certain areas belonging to certain tribes, although they do not have ownership.

In some cases the government has given parts of these lands to these tribes to be used as they want, especially for grazing of their animals. In most cases the government did not give the land to anybody. But there is sort of common law that if somebody cultivates a land for certain period of time he will have the right to claim ownership of that land. Accordingly, lots of people started to plow thousands of hectares every year to put their hands on these lands. Since there is no control in such behaviour vast areas have been devastated and thus desertificated through this behaviour.

8.5.3. Grazing

The marginal land has been used through time as a grazing land without any serious effect on the productivity of this land. Recently, the use of cars and trucks to follow up the moving herds with water and food subsidy during the dry seasons has destroyed great parts of the range

lands. In addition the huge increase in human population in Jordan has increased the demand on red meat. Accordingly number of animals has increased enormous to satisfy the need on this product. Therefore, great pressure has been exerted on the grazing land which led to overgrazing, loss of biodiversity and desertification.

8.5.4. Rural development

Increase in human population in Jordan has not just destroyed the fertile land of the mountains but rural development has spread to reach marginal land. For example the whole marginal area east of Amman and Zarka up to Mafraq and Ramtha has been all occupied by rural development, especially, Sahhab, Muwaqqer, Zarqa, Duleil, Khaldyiah, Mafraq and Ramtha.

Huge industrial areas and cities have been initiated within this land due to the cheap prices of these land and as a planning policy to push away the industrial areas from highly populated cities. This of course have destroyed the range land biodiversity and increase pollution. Another example that there are three universities at the time being has been initiated. In the same area as well as housing projects. This definitely will lead to the spread of human population and rural areas at the expense of rang land and biodiversity.

8.6. Eastern Desert

The Eastern Desert of Jordan, known as the Badia, is representing almost 80% of the total area of Jordan. Accordingly this vast area should not be ignored or left over without careful attention. Since it represents the future expansion of the country, then it should be seriously studied and invested on a well-planned scale.

The Eastern desert as previously mentioned in various parts of this book is characterized by having dry hot summer and cold winter with a rainfall ranges from 50-150 mm per annum at most. Temperature although, it is hot in comparison to the mountainous regions, but it is not as hot as one might think of the desert temperature in the Gulf region. Therefore, it is rather rich in vegetation and represents variable microhabitats or subclasses of vegetation types or specific ecosystems.

However, the vegetation in the desert classified as non-timber vegetation. This does not mean that there are no trees at all, but it means that the dominant vegetation is bushy type with some many herbaceous or ephemeral species in addition to some shrubs. For example in Wadi AL-Bottom, near Qasr Amra, there are well-developed trees of ***Pistacia atlantica.***

Some might consider these trees as penetration from the Irano-Turanian or even the Mediterranean to the desert. It might be the case, but still there are trees growing naturally in the heart of the Badia. The distributions of some of these trees have reached the borders with Saudi Arabia. There is also long, well developed and drought resistant trees of ***Tamarix arborea*** growing in the desert Oasis of Azraq.

The Badia region, considered as a range land in terms of land classification, that should not be used other wise. The vegetation such a barren area for the observer of non expert eye is rather very rich. One visit during the spring season will be enough to change this idea to the reverse. One can collect about two hundred species of well-adapted plants from a very limited area. The overall estimated species might be recorded in the whole E stern Desert could exceed one thousand. During the year 1993-1994 about 400 species were recorded from a limited area in the Badia Project.

The overall human impact on the Badia ecosystem bssusosib si as follows:

8.6.1. Overgrazing

This problem has been discussed previously in the marginal areas and problems such as: Increase numbers of animals, haphazard movement of vehicles and so on. But in addition to that Jordan acts as a crossing zone for the animals and herds coming in and out of Syria, Iraq and Saudi Arabia.

This problem of herd movement to Jordan from neighbouring countries becomes more serious in two occasions. First, whenever a good rain season occurs, usually plenty of green cover in the Eastern Badia will be available. Accordingly, animal herds especially from Saudi Arabia, Iraq, Syria and other parts of Jordan move into the Eastern Desert and cause severe overgrazing due to the dense gathering of animals that

exceeds the carrying capacity several times. Second, every year and according to the Haj Season (Islamic pilgrimage time) huge movement of animal herds coming from Turkey, Syria and Iraq often smuggled through Jordan to be sold and slaughtered in Saudi Arabia. This occurs yearly and in a limited period of time that causes even more serious problem of overgrazing.

8.6.2. Agriculture

Naturally, the Eastern Desert is not a suitable place for natural rainfed cultivation due to the prevailing dry conditions in the whole area. Within the past ten years, and still going on, vast areas of the Eastern Desert are now under irrigated cultivation for the use of vegetable crops or fruit trees. This was enhanced by the discovery of the huge underground water reservoir known as Azraq basin. This water is rather potable and in general with low percentage of salinity that has been used successfully for agriculture.

The agricultural activities in this dried area have led to the following sequences:

8.6.2.1. Range land destruction

The most promising and fertile land was used as sites for the new agricultural farms. Therefore, double effect was produced: first, the most fertile lands in terms of natural rich vegetation was totally destroyed; second, the primary useful vegetation was replaced by notorious weeds. This has led in many cases to the destruction and loss of biodiversity as well as desertification.

8.6.2.2. Soil salinity

Excessive use of water irrigation on saline soil has caused in some places the accumulation of salt at the soil surface due to the effect of evaporation. After few years there will be an effective accumulation of salt that causes a high range of soil salinity that inturn makes the soil in fertile and subsequently will be abandoned by the farmer, since it is not productive any more. This problem was clearly demonstrated in Azraq Oasis in and around as well as some parts in Mafraq governorate.

8.6.2.3. Pollution

Whenever agriculture is present it will be coupled with the use of fertilizers and pesticides automatically. The use of fertilisers and pesticides has led to the imbalance of the natural ecosystem in the Badia region. This imbalance was demonstrated in the loss of biodiversity in terms of plant and animal species.

8.6.3. Movement of Vehicles

Fifty years ago, the main method of movement and transport in the Eastern Desert was either camels or horses. Nowadays, all Bedouins and animal breeders have vehicles as the main methods of transport. Often each family of those has a water tank, a truck and a pickup. Since, the grazing animals are moving from one place to another, the family and their vehicles have to move with them. In some other times the family will be fixed in one place and the vehicles will follow them to take water, food subsidy or to collect milk and its products.

This haphazard movement in the Eastern Desert has led to destruction of great parts of the grazing land and destroyed the vegetation totally on some tracks used more often by vehicles. Consequently, great loss of biodiversity as well as loosening of soil particles have led to total desertification in some parts.

9. CONSERVATION

9. 1. Importance of conservation

9. 2. Methods of conservation

9. 3. Reserves in Jordan

9.4 Recommendations

9.1. Importance of Conservation

Human beings have been through history using plants, flora and biodiversity in general without much care about their status. The most important for people is to take what they want and to destroy what ever they think it is enough to establish a new farm or build a house, factory, air fields, golf yards, highways or any thing without serious considerations for the sequences.

Recently, individuals, people and governments have come to realize the dangerous acts of human all over the world. Much of the earth green cover has been destroyed and lots of plant and animal species have been recorded to be extinct. The advancement of the industry has enhanced the destructive effect in many ways:

i. Production of machines has facilitated and speeded the rate of destruction.
ii. Gases and chemical emissions have cases natural death of forest either by direct pollution or through acid rain.
iii. Increase of income has increased the need for food an expenditure, that means more destruction of green land for food production.
iv. Increase of the world population has lead to many things:

a. Increase in food needs and thus destruction of more land for farms.
b. Speed of cities and rural developments at the expense of fertile land.
c. Increase demand on wood for buildings.
d. Increase demand on wood for furniture.
e. Increase demand on paper production and thus forest destruction.
f. The irrational use of chemicals and pesticides has affected negatively the whole ecosystem, polluted air, water and sea.

As a result of the extensive damage of the ecosystems, pollution, over exploitation of natural resources and extinction, governments have started

to put legislation and legal systems to control the behavior of people and the use of the natural resources.

Most governments have started to impose rules to prohibit collection or the trade of plants and animals without special permissions. In addition governmental and none governmental organisations have started to care about protection of nature.

In late 1988's governments in collaboration with **UNEP** have formulated special committees of legal experts to discuss the articles of the global biological convention. This convention has been finally adopted by governments at Rio (Brazil) in June 1992. Lots of governments have already ratified and signed the agreements of this convention.

Since then lots of papers, publication and books have been produced in relation to biodiversity and the global biological diversity such as (**GROOMBIRDGE,** 1992; **COURRIER,** 1992).

9.2. Methods of Conservation

The aim of conservation in general is to protect the ecosystems, species, population and genes in different forms. To achieve these goals there have been several classical and modern methods to do that. These methods can be subdivided into two major groups as has been agreed upon in recent terms as ***Insitu*** and ***Exsitu*** conservation.

9.2.1. *Insitu* conservation

This means that plants should conserved in there local habitats of occurrence without having to transfer them to different places. The various methods of insitu conservation used in various places will be summarized as follows.

9.2.1.1. Conservation of ecosystem.

This type of conservation could be made to protect a whole system with a particular characteristics in a country when this system is highly threatened and would be very dangerous to leave it without protection. In Jordan for example the whole ecosystem of Juniper forest in southern was

highly threatened. This forest ecosystem is only restricted to the place and almost representing the Southern limit of distribution for this type in the Northern hemisphere. In addition, this forest ecosystem is representing a dry ecosystem that is highly degraded, overexploited as well as surrounded by almost desert conditions.

Based on the previous fact it was decided to announce that this forest should be protected and named as Dana Reserve. This reserve has rare, endangered and endemic species of highly valuable genetic resources. The reserve also represents three different biogeographical regions as previously mentioned.

9.2.1.2. Conservation of a special habitat

Protection of special habitat can be made when vast parts of the country has a particular type of a geographical region and this region is covered by certain type of vegetation or ecosystem. In this case one site or more that represent changes and local variations should be selected and protected as reserves to show the effect of protection and to conserve parts of the biological diversity in such habitats.

In Jordan series of these habitats reserves were established to protect particular part in the country. Examples of these are Shaumari reserve in the desert; Surra, AL-Khanasrah and Daba'a Reserve in the marginal land; AL-Fujaij and Zubia in the mountains. Zubia reserve was designed to protect the forest habitats of the extinct fallow deer in Jordan. Therefore, the reserve was initiated and the animal was reintroduced again to the same home land and same habitats.

9.2.1.3. Conservation of a restricted area

This type of conservation is restricted for the protection of a limited area of particular flora and fauna. For example, when agriculture expansion of cities or industries is replacing most of the lands that represent certain types of ecosystems. In this case what ever left should be protected. In some case few hectares are good enough for this purpose.

9.2.1.4. Conservation of a population.

Some times one cannot protect a whole ecosystem for various reasons, but still there is a population of a rare species under threat of extinction or has a limited distribution in the country, that must be protected. Example of that ***Cupressus sempervirens*** as wild species is restricted to Ain Lahtha in Tafila province. The whole population was less than 50 trees representing the only wild origin in Jordan. Such trees where fenced and protected form threat, until recently included within the Dana Reserve.

In Jordan all the orchid species are endangered, but some will be extinct for sure unless they are protected very soon, since their habitats are under daily change. I know few that will be replaced by buildings at most in the coming ten years. ***Himantoglossum affnei, Orchis sancta, O. punctatus, O. saccata*** and ***Epipactis veratrifolia*** are few examples.

Iris vartanii was collected once from Ras As-Salt, Salt province in 1984 **(AL-EISAWI,** 1986) as a new species to the flora of Jordan. Unfortunately, several times the same site has been visited, but the species has not been observed since. The whole area now is occupied by new houses.

9.2.2. *Exsitu* conservation

9.2.2.1. Botanical gardens.

It has been practiced during the past two centuries that collections of plants from varies parts of the world were brought to grow in botanical gardens of a city or country. Specific conditions were provided for some of these plants such as alpine plants, tropical plants, cactus plants etc. Such collections have served to conserve these plants away from their natural habits.

However, botanical gardens still can serve a continuous role in the future. The botanical gardens can be much more effective especially if they are more dedicated to collect and grow the plants of the same country, because variations in environmental condition can be minimized, care and coast needed will be also reduced.

9.2.2.2. Propagation using classical methods

Exsitu conservation often has to be relayed upon collection of seeds from the occurrence of the plants and taken to special laboratory, greenhouse or botanical garden to be propagated. Often sophisticated methods have to be used to break the dormancy of seeds or to over come unnatural conditions facing the seed germination as being transferred from their natural habitats.

In some cases vegetative propagation is used rather than seeds. Cuttings, bulbs, bulbils, corms, tubers, rhizomes or any other method can be used for propagation of the plants. The aim of all of these methods is to increase the number of the plants under investigation.

After the success in seed germination the aim should be to keep the plants to the stage of being able to transfer them to their natural habitats to fulfill the final goal of increasing the number of rare and endangered species. Again continuous observation for these plants should be followed to find out their behavior and adaptation to the present conditions.

9.2.2.3. Propagation using modern methods and biotechnology

Often classical methods of propagation cannot be satisfactory for the propagation of the plants under investigation. For example, all the classical methods of seed germination will not be successful in germinating some rare orchid seeds since they need specific symbiotic life. Using tissue culture for the same seeds adding in advance the needed mycorrhizae fungi, the seeds were able to germinate normally, and thus plants are produced.

Other examples can be given for the vegetative propagation of cacti, ferns and other ornamental plants.

This tissue culture method in some other cases would be the only salvage if the plant under investigation is sterile, with no chance of fast increase through seeds.

As given above modern aspects of biotechnology can be applied to the conservation of plants especially endemic, rare and endangered.

9.2.2.4. Seed banks and gene banks

In recent time and due to the enormous threats to the biological life in general as a result of science advancement in various fields especially nuclear physics, genetic transfer and biotechnology, there are chances of pollution or imbalance between organisms based on the release of alien engineered species, people have started to think seriously about conserving of what we have.

Serious efforts are gathered by various national and international organizations to conserve the genes of various wild and cultivated plants living on our earth as an ethical responsibility for the future generation and as a human heritage for man kind.

Based on what was previously mentioned active efforts at the local and regional levels are intensified to collect seeds of wild species of different parts of the world to keep the seed in seed banks, in fact as gene banks, under controlled condition to keep the seeds viable for the maximum period of time. The same thing is made for the races and varieties of cultivated plants that human has developed through his civilization life.

There are various methods to preserve seed such as vacuum, cooling, critical point of drying, tissue cultures and deep freezing. Intensive research is actually concentrating on this matter at the time being to find out the best conditions for each species or group of plants.

9.3. Reserves in Jordan

Jordan is considered to be one of the pioneer countries in the region in reserve initiation. The aim of these reserves was to make range land reserves in various parts of Jordan to show the effect of protection for the people in the Badia and in the country side. The main purpose of such reserves is to find out how much is the land under natural conditions can provide food in terms of biomass and how many species can grow, what are these species and the most important which species are palatable.

These aims were followed by how much is the productivity of these lands and what is the carrying capacity for none harmful grazing.

All of such reserves were initiated by the Ministry of Agriculture alone or in cooperation with some international organizations especially **FAO**. The reserves were based on conserving wild plants as occurring naturally in their ecosystems.

Later on there was an idea for enhancement of these reserves by either making contour lines with a width of about 50-70 cm. and either grow grazing herbs or shrubs. One of the ideas was to plant shrubs of the Australian Atriplex for grazing ***Atriplex nummularia.*** In some other cases another acacia species ***Acacia cyanophylla*** was also introduced to a wide range of distribution in Jordan.

Both species have survived and are growing in Jordan, but they can never compete with local species which have long history of adaptation to the local environment and have better distribution in various habitats. For example, the local ***Atriplex halimus*** has a huge range of distribution starting from the mountains to the marginal land, desert , Wadi Araba and even the high saline condition. On top of all the previously mentioned, it is eaten by Bedouin village people as a spinach as well as it is highly palatable by grazing animals. More over it can grow up to 3 meters or more in height under natural conditions.

This even applies for the various ornamental trees imported from the Northern hemisphere that need a high water budget at the time we suffer from the water shortage. Adding to that lots of them cause hay fever since their pollen grains have a previous reputation of causing allergy. We should go and select the trees that grow and flower under our natural condition, which resist drought, diseases and do not cause allergy.

The same thing can be said about the ***Acacia cyanophylla*** that it grows up to about three meters, resists drought, produces tiller which often do not allow the plant to grow high and has a limited distribution in the marginal land but nothing in the desert. The most fatal thing about this species that it does not resist frost. In 1992 Jordan was struck by a very cold winter and severe frost for about two continuous months, most of the acacia plants were almost dead. The work of about 30 or 40 years was almost gone regarding this species. It is always very important in the protection programme to concentrate on local, well adapted species.

At about 1946 the first range land reserve called Surra was initiated in Jordan and since then there are about 30 different reserves. Few of these reserves are under the control of the Royal Society for the Conservation of Nature(RSCN). In my opinion these are typical natural reserves since they are strictly initiated for this purpose and they are well controlled.

The rest of the reserves are also very important but they are from time to time badly grazed by herds people, Bedouins and animal owners. This happens quite often during drought seasons, when green cover is very little due to the unusual little amount of rainfall.This occurs at about a range of five years interval.

Nevertheless such reserves have proved to be important in protecting rare and endangered species and huge amount of seed stock as proved in previous studies (**HATOUGH et al.** 1986 ; **AL-SYOOF,** 1988). Some of the rare and new species were not found except in these reserves such as ***Crocus moabiticus, Eminium eximium, Achillea membranacea, Euclidium syriacum, Anthemis hyalina***. Therefore, the reserves in Jordan act as gene pool and genetical reservoir for the protection of biodiversity.

List 9.1 shows reserves in Jordan, their total area, year of initiation, purpose and responsibility.

List 9.1. Showing Reserves in Jordan, year of initiation, total area, purpose and responsibility. They are either under the responsibility of the Ministry of Agriculture (MA) or the Royal Society for the Conservation of Nature (RSCN).

Name of the reserve	Year of initiation	Total area km²	Purpose	Respons-ibility of
Shaumari	1975	22	protection	RSCN
Azraq Wetland	1977	12	protection	RSCN
Mujeb	1987	212	protection	RSCN
Azraq (Desert)	1987	320	protection	RSCN
Zubia	1988	10	protection	RSCN
Dana	1989	120	protection	RSCN
Wadi Rum	1989	560	protection	RSCN
Burq'	1993	950	protection	RSCN
AL-Khanasrah	1946	4.5	range	MA
Surra	1946	4	range	MA
AL-Fujaij	1958	10	range	MA
Daba'a	1968	3.96	range	MA
AL-Manshiyah	1968	3	range	MA
Sabha	1979	10.5	range	MA
Mujeb	1981	10	range	MA
AL-Lajoun	1981	11	range	MA
Et-Tawaneh	1981	20	range	MA
AL-'Aa'shiyah	1983	20	range	MA
Wadi Rajib	1983	4.5	range	MA
AL-Adasiyah	1983	20	range	MA
Ma'ein	1983	20	range	MA
Wadi AL-Bottom	1986	15	range	MA
Ras An-Naqab AL-Ra'awiyah	1986	12	range	MA
Eirah	1986	20	range	MA
Nakhil	1987	9	range	MA
AL-Azraq AL-Ra'awiyah	1987	300	range	MA

9.4 Recommendations

Generally speaking all types of vegetation suffer from destruction, heavy grazing and human over exploitation. Therefore, the following suggestions are listed to protect the natural vegetation:

1) Natural vegetation, especially the forests, should be protected and strict measures should be taken against those violating the law.

2) The cutting down of the limited forest areas in Jordan for cultivation and agriculture purposes should be abandoned.

3) Restrictions should be imposed on the cutting of trees for wood and coal production or any other destructive purposes.

4) Grazing, especially by goats, is one of the major causes of forest degradation in Jordan. Therefore, a reasonable solution should be found to solve this problem.

5) Some of the forests are privately owned and often commercially sold as house building material. This results in the destruction of critical vegetation cover. The government should protect these precious resources, either by purchasing or exchanging them with other non-forest lands.

6) Natural forests are commonly used by local people for pleasure as national parks. The misuse of such natural habitats through lighting fires and parking cars beneath the trees has damaged vast areas of such forests and delicate plants, especially the orchids growing on the floor of the forest. Therefore, tourism instruction and information must be provided to visitors to make use of and enjoy such places without much destruction.

7) Many rare species are considered to be threatened and should be protected.

8) Much of the marginal land at the Irano-Turanain borders has been used for cereal production. Because rainfall is irregular, such land will be deserted and the natural plants, used to grow there, will need a long time to re-establish themselves again. This is one of the most dangerous areas for possible desertification.

9) The desert of Jordan is not a typical desert, and some parts support reasonably good vegetation. if such places are protected they can be used for well organized grazing.

10) Natural reserves should be increased to protect as much as possible natural habitats and wildlife. The Shaumari reserve is one of the best examples of vegetation protection in the desert. If one compares the vegetation without the fence of the reserve with that directly outside of the fence, astonishing difference will be recognized.

11) Protection of some habitats, especially the degraded shrubby and the bushy Mediterranean vegetation, would provide an opportunity for regeneration of wood lands to a climax formation.

12) A project of reforestation should be adopted in Jordan by selecting the exact species for each specific habitat, but not using only one or two species everywhere. Not only that, but also it is important to maintain the reforested areas until the plants are well established. It is believed that this process should have more priority over planting new areas.

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